EVALUATION of MECHANIZED EGG-GRADING and PACKING EQUIPMENT

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EVALUATION OF MECHANIZED EGG-GRADING AND PACKING EQUIPMENT

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SUMMARY

Many types of egg-grading and packing equipment are available to the plant operator. They perform similar functions, but differ in degree of mechanization, capacity, cost, and labor requirements. Four representative systems of egg grading and packing, identified in this report as A, B, C, and D, were evaluated. Studies were conducted in plants utilizing these systems to determine ownership and operating costs, operating characteristics, and labor requirements.

System A, which provides for manual candling and packaging of eggs, is most effective for handling small lots of eggs of irregular quality. Equipment costs are relatively low and the system is simple to operate and maintain. However, it has a low production capacity and labor costs are generally high. It is imperative, therefore, that it be operated as efficiently as possible in order to hold labor costs to a minimum.

Systems B, C, and D, which provide for mass candling and automatic packaging, were designed for handling large lots of uniformly fine-quality eggs and should be used only for them. If small lots or lots of irregular quality are run on them, their purpose is defeated. Production will decrease and machine downtime will increase, resulting in a sharp increase in grading and packing costs.

System B has the advantage of selective automatic packaging. All eggs may be manually packaged or the predominant size classes may be packaged automatically. This arrangement provides for handling a manual operation to begin with and changing over to mechanization, as warranted by improvement in quality and lot size. If labor costs are low, manual packaging may be desirable. The system offers flexibility and low capital investment. Since the system is made up of several units, single units can be operated during slack periods while others are shut down without causing excessive operating losses.

System D offers extremely high and therefore economic production rates, but its effectiveness is restricted to operations handling a large volume of uniformly high-quality eggs. For this type of production, however, equipment costs are relatively low because of the high capacity of single units. On the other hand, slack periods during which maximum capacities are not used can result in costly equipment idle time.

System C provides for automatic packaging of all size classes. Since there is a minimum annual rental, nominal per-unit-equipment costs can be attained only by continuous operation. On the other hand, operating costs are lower than for the other systems because maintenance is furnished in the rental. Although labor utilization is effective, grading and packing costs are generally higher than for systems B and D when compared at normal operating levels. On the other hand, if the system is run at higher production levels (two shifts), the fixed equipment costs are prorated over a larger volume and this system rapidly reaches the effectiveness of systems B and D.

Many interrelated factors must be considered in the selection and utilization of egg-grading and packing equipment. Sound decisions cannot be made by considering the factors independently, but must be based on an analysis of the overall system. Manual-candling equipment should be available in all plants to handle occasional small lots or eggs of irregular quality, since even the most effective quality-control programs include occasional lots of poor quality.

A procedure was developed for estimating the cost per case to grade and pack various volumes of eggs annually at any labor rate with each of the systems studied.

BACKGROUND

For years, the grading and the packing of shell eggs were performed by workers at manual-grading benches (fig. 1). One worker—the grader—performed all or most of the basic operations required to grade and pack the eggs. He transferred full cases of eggs from stacks beside his work area to the grading bench, examined each egg for interior and exterior quality before a candling light (fig. 2), determined the size of each egg, packed the graded product, and also frequently had to obtain supplies of packing materials and dispose of the empty cases from which

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FIGURE 1.—Typical manual-grading bench. At center is candling light over case of ungraded eggs, with individual egg scale on right of light. Cartons for graded eggs are on either side.

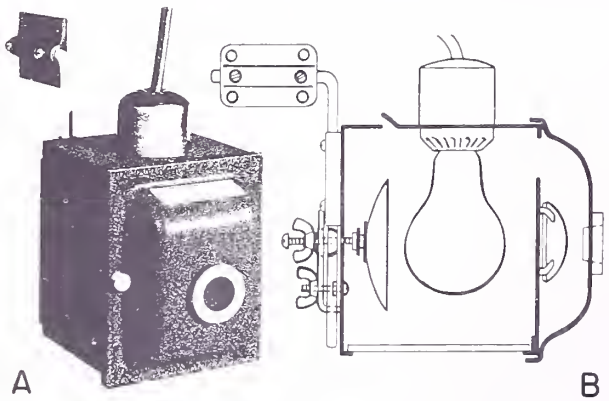

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FIGURE 2.—Widely used bench-type candling light (*A*), with section view (*B*).

the eggs had been graded. The grader determined the size of an egg by sensing its weight as he manipulated it. Occasionally eggs of doubtful weight were checkweighed on individual egg scales (fig. 3). The grader was also required to maintain an accurate count of the number of eggs of each quality and size in each producer lot.

This method of grading and packing eggs was time consuming, costly, fatiguing, and subject to error because of the many decisions in rapid succession that the grader had to make on each egg. Labor costs per unit of production were high, because the skill most difficult to acquire was not fully utilized. A grader's production was reduced considerably, because it was necessary to perform many auxiliary or housekeeping functions in addition to grading. If the grader's output was to

be increased, changes in method and equipment were necessary.

The first improvements in the fully manual-grading operation increased the grader's productivity by assigning some of the secondary functions to other workers. Overhead chutes for supplying packaging material to each grading bench (fig. 4), loaded by a worker other than the grader, provided the grader with a continuous supply of cartons within convenient reach. A belt conveyor extending the length of the grading benches was introduced for moving cartons of graded eggs from the benches to a central case-packing area. The belt routed cartons through mechanical closers and sealers onto a rotary packing table (fig. 5), from which they were packed into cases by another crew member. The belt arrangement had many variations, but all were based on the principle of moving the cartons of eggs

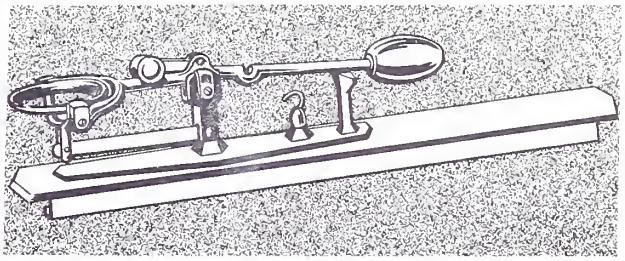

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FIGURE 3.—Beam-type individual egg scale.

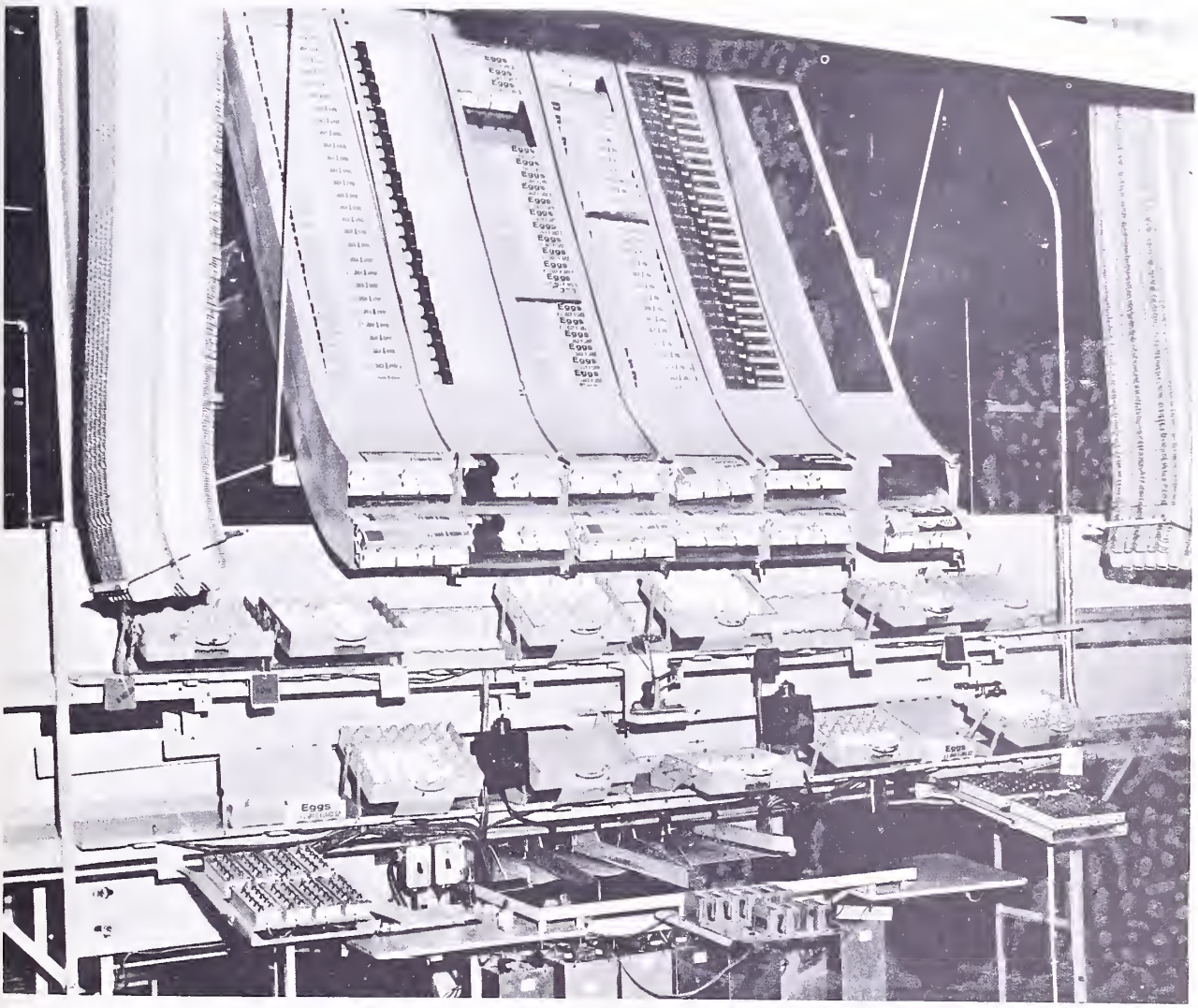

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FIGURE 4.—Overhead gravity carton chutes at two grading benches. Partly filled cartons are above candling lights. Filler flats are in receiving racks.

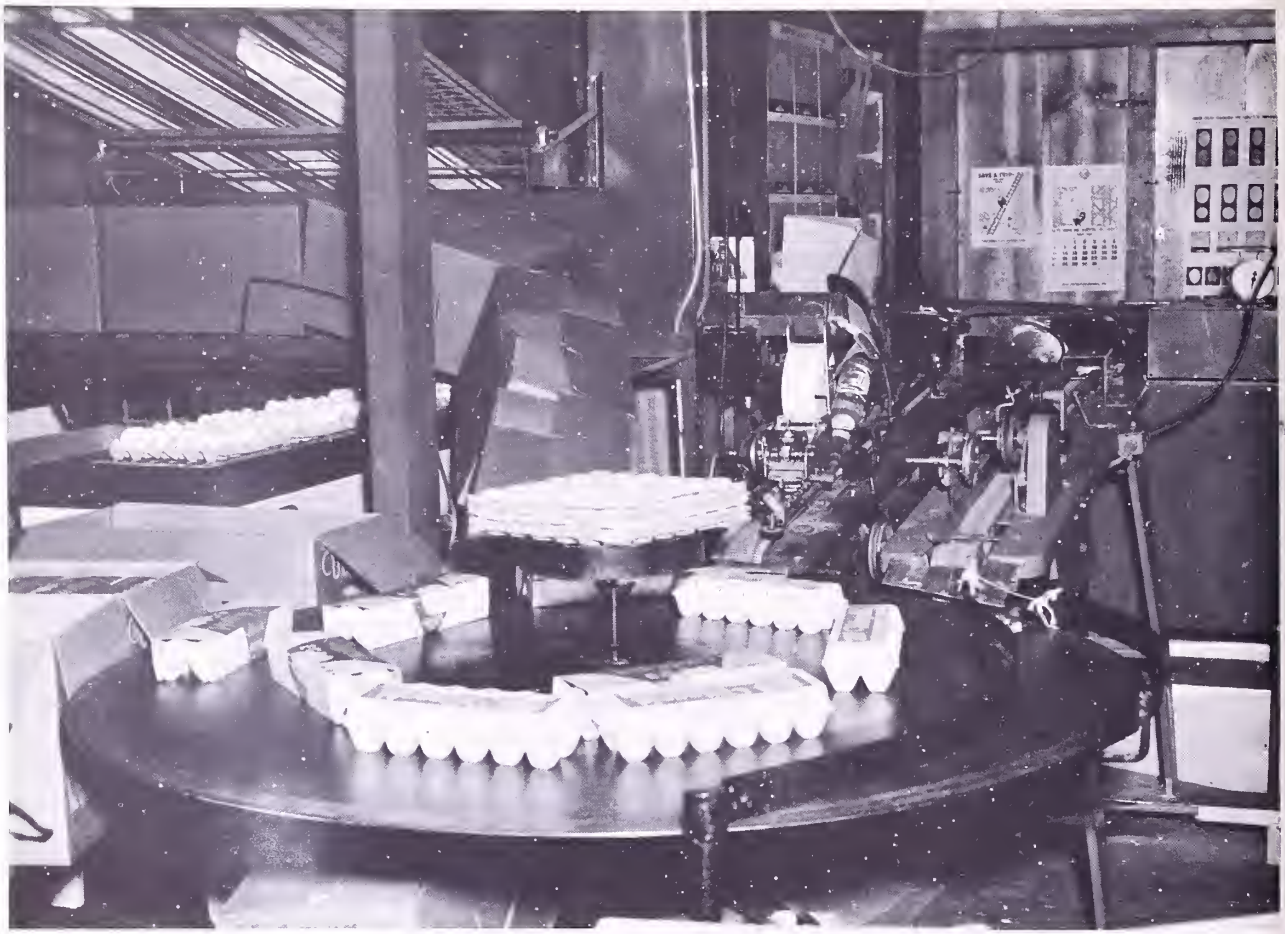

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FIGURE 5.—Cartons of graded eggs on 5-foot rotary packing table ready for packing. Mechanical closers and sealer in background.

from the grading benches to a central case-packing area.

In-line sizing, accomplished with individual egg scales in a conveyor that transports the ungraded eggs to the grading bench, was developed next, in an effort to reduce the number of decisions the grader had to make on each egg. Various sizing devices were developed, but all were basically the same, in that the eggs were placed on a conveyor and moved single file over successive in-line scales set for each shell egg-weight class.[1] Each egg was weighed as it was conveyed over the scales. An egg reaching the scale corresponding to its weight was transferred automatically to a tray in front of the grader. The trays were generally partitioned so that the eggs of each size remained separated. Since the eggs were presized, the graders had only to determine egg quality.

[1] "U.S. Department of Agriculture Regulations Governing the Grading of Shell Eggs and United States Standards, Grades, and Weight Classes for Shell Eggs, July 1, 1964."

Manually removing the eggs from cases and placing them on a single-file conveyor for in-line sizing was time consuming. This led to the development of an infeed conveyor six eggs wide (fig. 6) and vacuum- and spring-type multiple egg lifters (fig. 7). Ungraded eggs were loaded onto the infeed conveyor 30 or 36 at a time in 6-abreast formation. (Ungraded eggs are generally in filler flats of 30-egg capacity.) A device at the runoff end of the conveyor arranged the eggs in single file for movement over the in-line scales.

Electrical counting and tabulating devices were developed to reduce the time required to inventory producer lots. These devices were incorporated in the scales or the belt arrangement for moving packages of graded eggs to the case-packing area.

Each of these improvements reduced the number of manual time-consuming operations formerly performed by the grader, whose job was then limited to candling and packaging eggs in cartons or filler flats. They increased the output and quality of workmanship and reduced the amount of

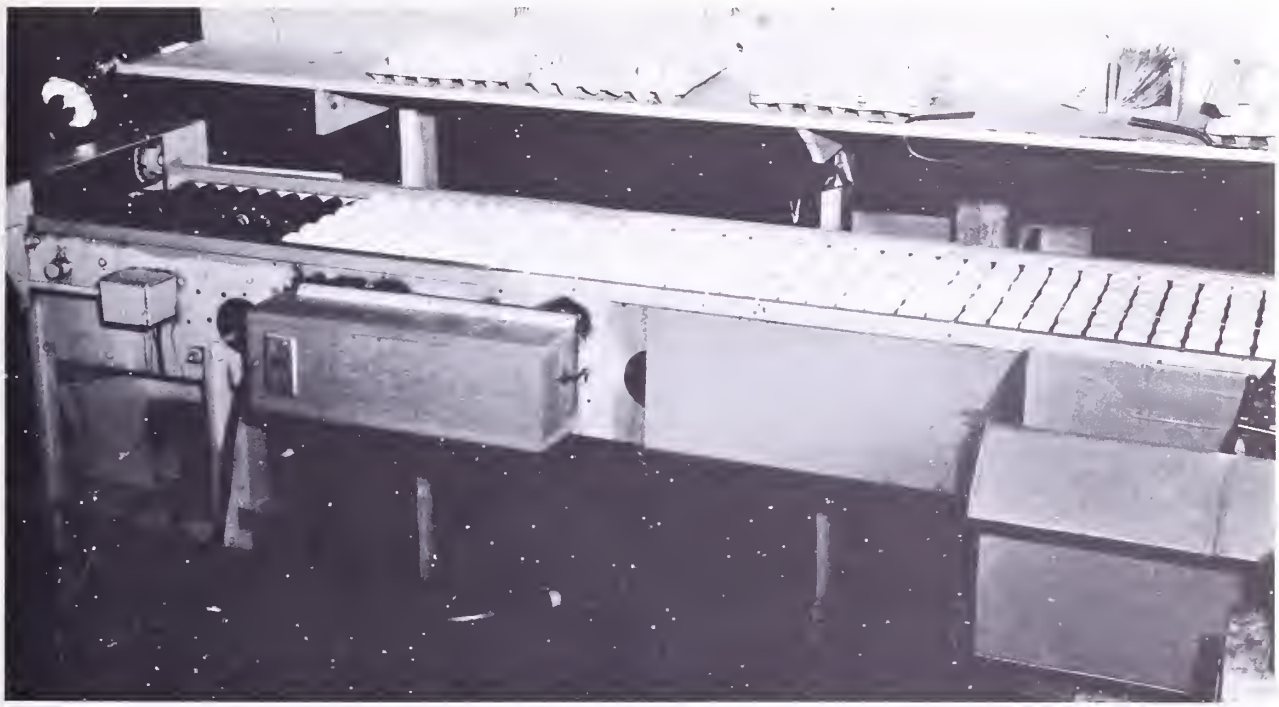

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FIGURE 6.—Infeed conveyor with spool-type rollers capable of handling eggs six abreast.

physical effort required for grading and packing.

In recent years, large-scale commercial egg production has increased, accompanied by improvement in egg quality due to better breeding, production, and farm-management practices. This trend toward better quality has been accelerated by an increasing consumer demand for eggs of uniformly fine quality, which has caused egg-packing plant management to encourage producers to deliver large lots of eggs of uniformly fine quality. Quality-control programs came into being and producers were paid a premium for eggs produced under management-guided quality programs. There are many quality-control programs, most of which are patterned after the U.S. Department of Agriculture "Fresh Fancy" program,[2] in that they require producers to follow production and farm-management practices that insure eggs of uniformly fine quality.

The increasing number of large lots of eggs of uniformly fine quality reaching the packing plant led to the next innovations in egg-grading and packing equipment. Candling each egg before a candling light to determine quality was no longer essential with this type of product. Only a small percentage of the eggs were undergrades, and most of these were easily recognized because of their checked, stained, dirty, or leaking condition. Recognition of this fact led to the introduction of the principle of mass candling, or flash candling.[3]

A part of the infeed conveyor is underlighted. The grader examines the eggs as they are conveyed over the underlit area of the conveyor and removes and packs undergrades. This has greatly increased the productivity of graders, since they remove only undergrade eggs at the light instead of handling all the eggs.

Development of mass candling stimulated further mechanization of the egg-grading and packing operation. Existing mechanized equipment was improved and capacities were increased. Improvements were made on infeed conveyors, underlighting, in-line sizing devices, and inventory systems. The latest innovation in egg-grading and packing equipment was automatic packaging.[4] These developments have increased the output per man-hour of labor and have resulted in a more uniform pack of fine-quality shell eggs.

Several types of mechanized egg-grading and packing equipment are now available to the plant operator. They perform similar functions, but differ in degree of mechanization, capacity, cost,

[2] See footnote 1, p. 4.

[3] HAMANN, JOHN A., WINTER, EVANS R., STOYANOFF, ROBERT, and HESTER, O. C. ELECTRONIC BLOODSPOT DETECTION IN COMMERCIAL EGG GRADING. U.S. Dept. Agr. Mktg. Res. Rpt. 239, 65 pp., illus. 1958.

[4] WINTER, EVANS R. AUTOMATIC SIZING AND PACKAGING OF EGGS. U.S. Dept. Agr. Mktg. Res. Rpt. 424, 17 pp., illus. 1960.

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FIGURE 7.—Five by six or 30-egg multiple egg lifters: Left, vacuum type; right, spring type.

size, and labor requirements. The increase in mechanization has resulted in a corresponding increase in equipment costs. It is most important therefore that the selection and utilization of equipment be based on a sound cost evaluation.

The purpose of this study was to evaluate mechanized egg-grading and packing equipment and the systems in which they are used to determine the production capacities and grading and packing costs. The object was not to determine which system was best, but rather to develop guidelines for equipment selection that would result in maximum effectiveness within individual volume and quality situations.

SELECTION OF SYSTEMS FOR STUDY

There is a basic-equipment unit for each type of egg-grading and packing system. This is generally one principal machine unit, which is combined with similar units and the necessary auxiliary equipment to make up a commercial egg-grading and packing line. For the purpose of this study, an egg-grading and packing system is defined as one or more basic-equipment units of the same type and the auxiliary equipment required to operate it under commercial conditions. It is not uncommon to find a combination of the various equipment types being used in one plant. For evaluation purposes, however, each system was considered to consist of one equipment type.

It would be repetitive and impractical to include all the different types of equipment in all combinations of usage in a study of this kind. It was necessary therefore to select only the most typical equipment for evaluation purposes. Auxiliary equipment, such as washers, check detectors, and bloodspot detectors, is generally optional and was not considered in this study.

The basic-equipment units selected for study were (1) an 11½-case-per-hour unit that provides for in-line sizing and manual candling and packaging of all shell egg-weight classes—*system A;* (2) a 20-case-per-hour unit that provides for mass candling, in-line sizing, and manual packaging or automatic packaging of up to five egg-weight classes—*system B;* (3) a 35-case-per-hour unit that provides for mass candling, in-line sizing, and automatic packaging of all six weight classes—*system C*; and (4) a 60-case-per-hour unit that provides for mass candling, in-line sizing, and automatic packaging of from two to five egg-weight classes—*system D.*

These four equipment types include manual and mass candling and manual and automatic packaging of all weight classes and a combination of manual and automatic packaging. They vary in capacity, degree of mechanization, floor-space requirements, and ownership and operating costs. They include a rated production-capacity range of 11½ to 60 cases per hour. These equipment types were considered representative of those used in industry.

PROCEDURES

Commercial plants were selected for study on the basis of type of equipment utilized, quality and volume of eggs handled, quality of workmanship, plant layout, and overall operating efficiency. To be acceptable for evaluation purposes, a plant had to meet the following requirements: (1) Efficiently utilize one or more basic units of the equipment types selected for study; (2) handle eggs produced under the U.S. Department of Agriculture "Fresh Fancy" or a similar management-guided quality program; (3) operate under the U.S. Department of Agriculture grading program to verify quality of workmanship; and (4) operate in a well-designed facility with an efficient equipment layout. The Department grading program provided an effective check on the quality of workmanship and machine treatment of the eggs.

Studies were conducted in one or more plants utilizing each type of equipment and meeting acceptability requirements.

The number of basic-equipment units and the amount and type of auxiliary equipment used varied depending on the particular needs of the case-study plants. It would be difficult to locate plants that employed all the desirable equipment components of each system with equal output potential. Since it was desirable to evaluate each type at maximum operating efficiency and under similar operating conditions, the available installations were studied under existing conditions, and, where necessary, balanced, efficient operations were synthesized.

The following determinations were made for each equipment type: (1) Equipment requirements and specifications, such as capacities,[5] floor-space requirements, and power requirement; (2) equipment-operating characteristics, such as effectiveness and downtime; (3) actual hourly output or production; (4) equipment ownership and operating costs; (5) quality and size distribution of eggs handled; (6) average producer lot size; (7) types of packing materials used; (8) work methods employed; (9) quality of workmanship; and (10) labor requirements.

[5] The actual hourly output or production for each system was found to differ from that of the rated capacity because of machine downtime, unavoidable delays by the operators, and production lost while inventorying producer lots. The percentage difference in rated and actual capacity varied among systems.

The systems were evaluated on the basis of labor and equipment requirements and costs to grade and pack 100 cases of eggs. An assumed average wage rate of $1.75 per hour was used for all systems (see Appendix for details). Equipment ownership and operating costs were based on the annual production capacity of a system, assuming it was operated for one 8-hour shift (2,000 hours' annual use of the equipment). Equipment costs per 100 cases of eggs are therefore prorated over different annual volumes, depending on the capacity of the system. Equipment costs (detailed in the Appendix) and specifications were determined from plant records and verified by equipment manufacturers. Power rates prevailing in each plant were obtained from plant records.

The quality and size distribution of the eggs, the average size of producer lots, and the types of packing materials used were also obtained from plant records and confirmed by direct observation. Labor requirements, equipment-operating characteristics, and production data were determined by motion and time study, work sampling, production studies, and other industrial engineering techniques.

Combinations of basic-equipment units that were most effectively utilized and generally employed in commercial operations were synthesized.

The grading and packing costs for the synthesized operations were determined by projecting the findings from the commercial to the synthesized operations.

Suggested general layouts were developed for each system that would maintain the same general product flow regardless of the number of basic-equipment units utilized.

To insure that the systems were performing identical functions and were considered on a common base, the following variables were controlled:

(1) *Equipment*—the type and arrangement of auxiliary equipment were the same for all systems.

(2) *Layout and flow of product*—the layout of equipment and the general flow of product and materials were similar.

(3) *Product*—producer lots of 20 cases each of 90 percent A-quality eggs of uniform size distribution were supplied to all systems.

(4) *Packaging*—90 percent of the A-quality eggs were packaged in molded pulp 12-egg cartons and the remainder in 30-egg filler flats. Undergrades were also packaged in filler flats.

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EVALUATION OF SYSTEMS

System A

In system A, the candling and packaging of eggs are done manually and sizing and inventorying are mechanized. The basic-equipment unit consists of an infeed conveyor that operates at the rate of 11½ cases (4,140 eggs) per hour, an in-line sizer, a manual-grading bench with two bench-type candling lights, overhead chutes for supplies of empty cartons and filler flats, racks for holding filler flats and cartons as they are packaged, and electrical counters that operate in conjunction with the racks.

Operations incorporating two, four, and six basic-equipment units (23, 46, and 69 cases of eggs per hour) were synthesized and evaluated. These units are more efficiently utilized in multiples of two and generally are employed in this manner in commercial operations. The equipment layout (fig. 8) maintains the same general product flow for the three sizes of operation. For the overall operation for six basic-equipment units, the layout occupies approximately 1,900 square feet.

Auxiliary equipment with each size of operation consists of an overhead conveyor for empty cases (D), a package conveyor (H), a bulk-packing bench (I), carton closers and sealers (J), an 8-foot rotary packing table (K), and a case-sealing station (L).

To operate the equipment at capacity, crews of 7, 12, and 17 workers, respectively, are required: (1) For the 2-unit operation—1 floorman, 1 loader, 4 graders, and 1 case packer; (2) for the 4-unit operation—1 floorman, 2 loaders, 8 graders, and 1 case packer; and (3) for the 6-unit operation—1 floorman, 3 loaders, 12 graders, and 1 case packer. The crew members are shown diagrammatically at their work stations on the equipment layout (fig. 8). The work performed manually and by machine and the flow of product and materials through the grading and packing operations are described below. The work performed by crew members is the same for the three sizes of operation, except as explained in the description.

Description of Operations and Product Flow

Supplying Cases of Ungraded Eggs.—The floorman supplies cases of ungraded eggs to the grading line in pallet loads of 30 cases (each case holds 30 dozen eggs), moving them from a cooler or storage area as needed. These loads are placed between alternate infeed conveyors C, as shown in figure 8, and thus provide a supply of full cases convenient to each infeed conveyor.

Supplying Eggs.—One loader supplies eggs to the infeed conveyors C of two basic-equipment units. He transfers two full cases of ungraded eggs from the pallet P_u to the full-case bench A when only one full case remains on the bench. (The bench provides space for three cases.) He opens each case, removes the top filler flat from one side of the case, and places it on the stack of six filler flats of eggs in the other side of the case. He removes eggs with a 30-egg spring lifter and places them on the infeed conveyor C. The conveyor is six eggs wide and its length provides space for the equivalent of seven filler flats of eggs when it is fully loaded. As the loader removes eggs from the first side of the case, he stacks the empty filler flats on the other side. When the first side is empty, he transfers the accumulated empty filler flats to shelf B, and as he removes eggs from the other side of the case, he places the empty filler flats directly on the other stack on shelf B.

The eggs on the infeed conveyor C advance six-abreast toward the scale F (in-line sizer). The conveyor changes the egg arrangement to single file for movement over the scales.

Part of the infeed conveyor is overlighted to permit the detection and removal of eggs with exterior defects. The loader examines the eggs as they advance on the conveyor, removes leakers, and places them in trays on shelf B.

On each trip to an infeed conveyor, the worker loads it to capacity or with enough eggs so that it will not run empty before he returns to load it again. This insures an uninterrupted flow of eggs and reduces the number of trips between work stations by the loader.

As he empties each case, the loader places it on the overhead conveyor D for movement to the case-packing area, and he transfers the stack of 14 empty filler flats on shelf B to bench E. When two leaker trays accumulate on shelf B, he places them on bench E. At times when both conveyors are loaded or the machine is stopped, he places the leaker trays and the empty filler flats on the floor at the end of the infeed conveyors. The trays and flats are removed from the grading area by other workers.[6]

Sizing.—The in-line sizer F consists of five individual beam-type scales, adjusted to respond to the minimum weight for the jumbo, extra large, large, medium, and small shell egg-weight classes.

[6] The leaker trays are picked up periodically by a worker from the egg-breaking room and the empty filler flats by a materials handler. This work was not included in the study because of the variability of occurrence and final destination of the items and because the workers performing these brief tasks are regularly assigned to other plant operations.

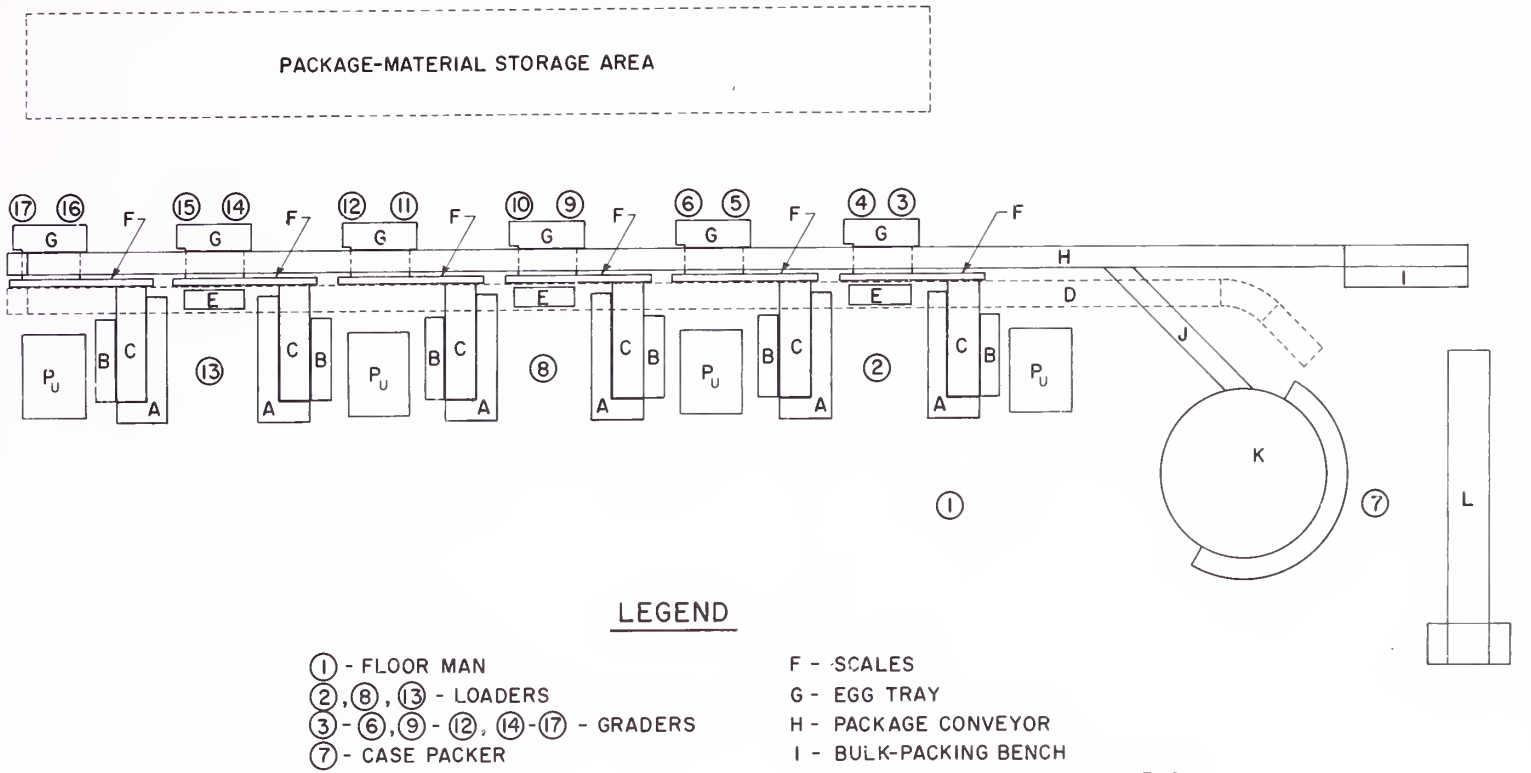

FIGURE 8.—Layout of equipment for egg-grading and packing operation in system A.

The eggs move single file over the scales. An egg heavier than a scale adjustment depresses the scale beam, which activates the ejector mechanism. The egg is ejected onto a divided belt that moves the egg to that section of the egg tray *G* for its size class. The tray is divided by movable partitions so that varying rates of each size class can be handled. There is no scale for peewee eggs, but all eggs that are not ejected at one of the five scales are automatically ejected at the end of the scales.

Candling and Packaging.—Four graders are required to candle and package the production from two basic-equipment units. The graders obtain the presized eggs from egg tray *G* and candle them at bench-type candling lights. After they determine the quality of the eggs, the graders place them in cartons or filler flats for their respective quality and size class. The empty cartons and filler flats are obtained from overhead chutes at each grading bench and placed on racks adjacent to and at the same height as the package conveyor *H*. After filling a carton or filler flat, the grader pushes it onto the package conveyor for movement to the case-packing area.

Inventorying.—All the eggs in a producer lot are graded and packaged on one basic-equipment unit. After all of them have been candled and packaged, two graders take the inventory.

The inventory equipment consists of electrical counters for each quality and size class. The counters operate in conjunction with the racks that hold the cartons or filler flats while they are filled. When a carton or filler flat of graded eggs is pushed from its rack onto the package conveyor *H*, the counter is activated. The egg count for the package is tabulated on the counter dial for its quality and size classification. At the end of each producer lot, the number of eggs that have been pushed onto the belt is recorded on the counter dials.

The eggs in partially filled packages on the bench are recorded manually by use of auxiliary counters adjacent to each rack. The grader depresses simultaneously one button that corresponds to the location of the last full row of eggs in the package and another button that corresponds to the location of the last egg in the row below the last full row. The number of eggs in the package is automatically recorded on the counter dial corresponding to its quality and size class. One of the graders obtains the leaker count from the loader and records it together with the totals for each quality and size class on the producer ticket for the lot. While one grader is completing the inventory, the other clears the counters and begins candling the eggs from the next producer lot.

Supplying Packaging Material.—Bundles of empty cartons and filler flats are stored in the package-material storage area behind the graders. The floorman transfers cartons and filler flats to the overhead chutes at each grading bench as needed.

Packing Cases.—Cartons and filler flats of graded eggs are moved from the grading benches to the case-packing area by the package conveyor *H*. Cartons are guided through the carton closer and sealer *J* onto the 8-foot rotary packing table *K*. Filler flats of eggs are moved to the bulk-packing bench *I* at the end of the conveyor. Both cartons and filler flats of eggs are packed into cases holding 30-dozen eggs.

The case packer obtains empty cases from the overhead empty-case conveyor *D*. This conveyor consists of a 12-inch belt conveyor and a 12-inch gravity-wheel conveyor with a 45-degree curve and a 5-foot straight section. Empty cases placed on the belt conveyor by the loader move to the end of the belt and onto the 45-degree curved section of the wheel conveyor above the carton closer and sealer *J*. They are then moved by gravity to the end of the conveyor.

The case packer removes two cartons of eggs at a time from the rotary packing table *K* and packs them into cases on the bench adjacent to the table. When six filler flats of eggs accumulate on the bulk-packing bench *I*, the case packer walks to the bench and packs them one at a time into cases. As cases are filled, he closes them and places them on the gravity-wheel conveyor of the case-sealing station *L*. Periodically the case packer for two- and four-unit operations or the floorman for the six-unit operation seals the cases and places them on the graded-egg pallet P_G for their particular order. Since the case-sealing station will hold 15 cases, this operation can be performed at times when the case packer or floorman is not working elsewhere.

Production Rates and Labor Requirements

The average output of one basic-equipment unit, when operated at capacity in a commercial operation handling eggs that are 90 percent A quality, is 9.5 cases per hour. The synthesized operations for the 2-, 4-, and 6-equipment units have capacities of 19, 38, and 57 cases per hour, respectively, or 38,000, 76,000, and 114,000 cases per year (table 1). Annual capacities are based on 2,000 hours' annual operation at the average hourly production rate. The elapsed time to grade and pack 100 cases of eggs is 5.26, 2.63, and 1.75 hours, respectively, with the 2-, 4-, and 6-equipment units.

The total labor required to grade and pack 100 cases of eggs with these units is 31.97, 29.35, and 28.92 man-hours, respectively (table 2). Labor utilization for the four- and six-unit operations is more effective than for the two-unit operation because the time of the case packer is more fully utilized. No unproductive time is shown for the

TABLE 1.—*System A (manual candling and packaging): Production rates and labor and equipment costs to grade and pack 100 cases of eggs with 2-, 4-, and 6-equipment units*

Equipment units	Crew size	Elapsed time per 100 cases	Production [1]		Cost per 100 cases		
			Per hour	Per year (2,000 hours' operation)	Labor [2]	Equipment [3]	Total
	Workers	*Hours*	*Cases*	*Cases*	*Dollars*	*Dollars*	*Dollars*
2	7	5. 26	19	38, 000	55. 95	5. 94	61. 89
4	12	2. 63	38	76, 000	51. 36	5. 07	56. 43
6	17	1. 75	57	114, 000	50. 61	4. 86	55. 47

[1] Based on hourly production rate of 9.5 cases per equipment unit.

[2] Based on labor requirements in table 2 and wage rate of $1.75 per hour.

[3] All equipment is assumed to be operating during entire elapsed time. Hourly equipment costs are given in appendix tables 10–12. Equipment costs are based on total annual production.

floorman in table 2 because he is available to perform other plant operations.

The loaders are unproductive for 2.34 man-hours in all three sizes of operation, indicating poor labor utilization. However, the distance between infeed conveyors and the length of time that a loader can be away from a machine when it is operated at capacity prevent assigning additional conveyors to the loaders. The graders (two at each basic-equipment unit) are idle 2.10 man-hours per 100 cases because of machine downtime and inability of the equipment to deliver eggs at the rate at which the graders can candle and package them. The equipment limits production to an average of 4.75 cases of eggs per hour per grader. If a continuous supply of eggs were provided, a grader could candle and package eggs of 90 percent A quality at the rate of 5.26 cases per hour. Unproductive labor of the case packer decreases as the number of equipment units increases. For the six-

TABLE 2.—*System A (manual candling and packaging): Labor required to grade and pack 100 cases of eggs with 2-, 4-, and 6-equipment units*

Equipment units, elapsed time, and type of worker	Workers required	Labor required		
		Productive	Unproductive	Total
2 units, 5.26 hours:	*Number*	*Man-hours*	*Man-hours*	*Man-hours*
Floorman	1	0. 41	(1)	0. 41
Loader	1	2. 92	2. 34	5. 26
Grader	4	18. 94	2. 10	21. 04
Case packer	1	2. 04	3. 22	5. 26
Total	7	24. 31	7. 66	31. 97
4 units, 2.63 hours:				
Floorman	1	. 42	(1)	. 42
Loader	2	2. 92	2. 34	5. 26
Grader	8	18. 94	2. 10	21. 04
Case packer	1	2. 04	. 59	2. 63
Total	12	24. 32	5. 03	29. 35
6 units, 1.75 hours:				
Floorman	1	. 87	(1)	. 87
Loader	3	2. 92	2. 34	5. 26
Grader	12	18. 94	2. 10	21. 04
Case packer	1	1. 65	. 10	1. 75
Total	17	24. 38	4. 54	28. 92

[1] No unproductive labor is charged to floorman, because he is available for other plant work.

unit operation, part of the work done by the case packer (sealing cases) must be done by the floorman.

Egg-Grading and Packing Costs

The labor and equipment costs to grade and pack 100 cases of shell eggs with 2, 4, and 6 basic-equipment units of system A are shown in table 1. As the annual volume handled and the number of basic-equipment units increase, the labor and equipment costs per 100 cases of eggs decrease because of more effective labor and equipment utilization.

System B

System B provides for mass candling, mechanized sizing and inventorying, and either manual or automatic packaging of up to five shell egg-weight classes. The basic-equipment unit consists of an infeed candler (a conveyor underlighted for mass candling) that operates at the rate of 20 cases (7,200 eggs) per hour, an in-line sizer, electrical counters that operate in conjunction with the sizer, a conveyor to supply cases of ungraded eggs, and, for all-manual packaging, 6 manual-packaging trays to hold accumulated eggs, with overhead chutes for supplies of empty cartons and filler flats.

Automatic packaging of three shell egg-weight classes was studied (this is referred to here as combined automatic and manual packaging). For this operation, three of the manual-packaging trays are replaced by three automatic packers—one for each of the major size classes of eggs (extra large, large, and medium).

Operations incorporating 1, 2, and 3 basic-equipment units (20, 40, and 60 cases of eggs per hour) for all-manual packaging and for combined automatic and manual packaging were evaluated.

Figure 9 shows the equipment layout for combined automatic and manual packaging for the three sizes of operation. This arrangement occupies approximately 2,800 square feet for the overall operation for three basic-equipment units.

For all-manual packaging operations, the additional manual-packaging trays (same size as trays *G*, *H*, and *I* with similar spacing) would be located in the area occupied by the automatic packers. Total area occupied for the three-unit operation would be about 2,725 square feet.

Auxiliary equipment with each operation is similar to that of system A and consists of an overhead conveyor for empty cases (*E*), a package conveyor (*K*), a bulk-packing bench (*L*), carton closers and sealers (*M*), an 8-foot rotary packing table (*N*), and a case-sealing station (*O*).

To operate the equipment at capacity when all eggs are manually packaged, crews of 5, 8, and 11 workers, respectively, are required: (1) For the 1-unit operation—1 floorman, 1 loader-candler, 2 packagers (not shown in fig. 9), and 1 case packer; (2) for the 2-unit operation—1 floorman, 2 loader-candlers, 4 packagers, and 1 case packer; and (3) for the 3-unit operation—1 floorman, 3 loader-candlers, 6 packagers, and 1 case packer.

For combined automatic and manual packaging, crews of four, five, and seven, respectively, are needed: (1) For the one-unit operation—one floorman, one loader-candler, one machine-tender-packer, and one case packer; (2) for the two-unit operation—one floorman, two loader-candlers, one machine-tender-packer, and one case packer; and (3) for the three-unit operation—one floorman, three loader-candlers, two machine-tender-packers, and one case packer. The work stations of the crew members required for combined automatic and manual packaging are shown on the equipment layout (fig. 9). For all-manual packaging, the additional workers would be at manual-packing stations, which would replace the packing machines *J*.

The operations for the three sizes of equipment combinations and two types of packaging are the same, except as explained in the following description.

Description of Operations and Product Flow

Supplying Cases of Ungraded Eggs.—The floorman supplies cases of ungraded eggs in pallet loads, as described in system A. He places the pallets P_u at the end of the full-case conveyors *A* and transfers cases to the conveyor.

Supplying and Candling Eggs.—The loader-candler pulls cases of eggs from conveyor *A* onto bench *B*. He opens each case, removes the two top filler flats, and stacks them on shelf C_1. Using a vacuum lifter, he transfers two groups of 30 eggs each to the infeed candler *D* and at the same time removes the emptied filler flats and stacks them on shelf C_1. He repeats this procedure until all the eggs in a case have been transferred to the infeed candler.

The infeed candler is six eggs wide and provides space for the equivalent of nine filler flats of eggs when fully loaded. The loading end of the infeed candler is lighted from above to permit detection and removal of eggs with exterior defects. The loader-candler places eggs with exterior defects in leaker trays or filler flats on shelf C_1. Eleven rows of the infeed candler are lighted from below. The loader-candler examines the eggs as they move over the underlit area and removes the remaining undergrades, placing them in filler flats on rack C_2 or shelf C_1. He places empty cases on the overhead conveyor *E* for movement to the case-packing area.

The loader-candler must vary the number of eggs loaded onto the conveyor and the number of

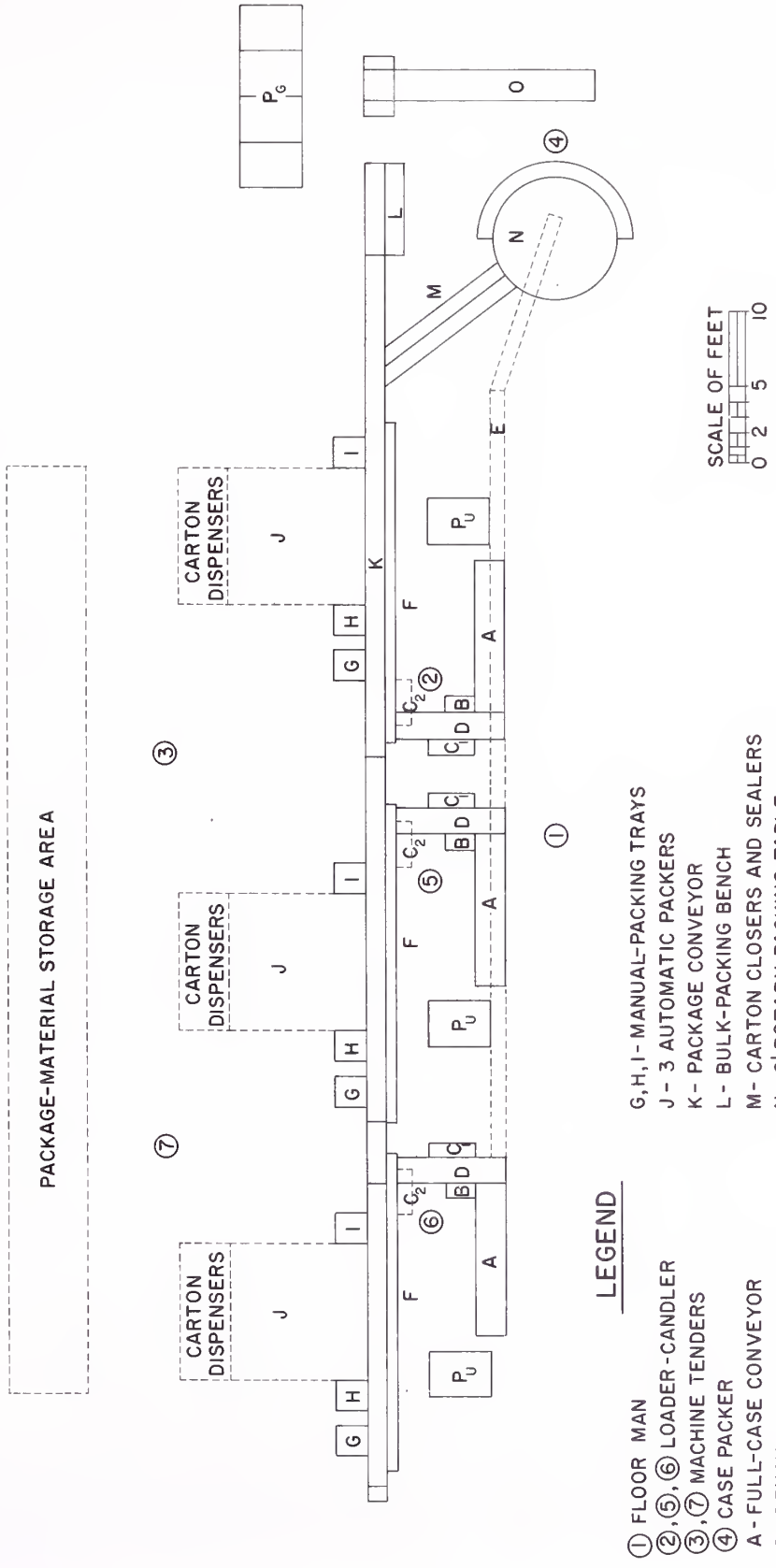

FIGURE 9.—Layout of equipment for egg-grading and packing operation in system B.

eggs examined each cycle to insure that no eggs pass the underlit area without being examined. At times when the conveyor has been loaded, the eggs over the underlit area have been examined, or when the machine is stopped, he removes the stack of empty filler flats and the leaker trays from shelf C_1 and places them on the floor beside conveyor A for pickup by the other workers.[7]

When a filler flat of undergrades accumulates in rack C_2, the loader-candler pushes the flat from the rack onto the package conveyor K for movement to the packing area. When a filler flat of undergrades accumulates on shelf C_1, he places it on the package conveyor K. The spaces on the conveyor from which undergrades are removed are filled with eggs from a spare supply on shelf C_1 when time allows. These eggs must be from the producer lot being run so that they will be included in the inventory for the lot. The eggs are moved six abreast on the infeed candler D to the end of the conveyor, where they are rearranged in single-file formation for movement over the in-line sizer.

Sizing and Inventorying.—The in-line sizer is of the same type as that used in system A. Eggs of each size class are ejected from the scales F at the packing station for their size. Peewee eggs are automatically removed from the scales at the last packing station on the line.

The inventory equipment for system B consists of electrical counters that operate in conjunction with the in-line sizer. Each egg ejected from a scale is automatically recorded on the counter for its size class. Counters also record eggs in filler flats pushed on the package conveyor from rack C_2. Individual pushbutton-type counters are provided for those classifications packaged in filler flats or leaker trays on shelf C_1. As each egg is placed in the filler flat or leaker tray, the worker depresses the button corresponding to the egg classification.

The loader-candler takes inventory at the end of each producer lot. Six empty rows are left on the infeed candler between producer lots so inventory can be taken without stopping the machine. When the sound of the counters' tabulating stops, the loader-candler knows that the last egg in the lot has been counted. At the end of a lot, the only eggs that have not been recorded are those in the partially filled filler flats in rack C_2. Auxiliary counters like those used in system A are provided at each filler-flat position. The worker tabulates these eggs by pressing buttons corresponding to the location of the eggs within the flat. He then records on the producer ticket the egg count that appears on the dials of the counters for each quality and size class and clears the counters for the next producer lot.

[7] See footnote 6, p. 8.

Manual Packaging and Supplying Packaging Material.—The packagers obtain eggs from the trays G, H, and I and place them in cartons or filler flats on racks at each packaging station. The racks are at the same height as the package conveyor K. When a carton or filler flat is filled, the worker pushes it from the rack onto the package conveyor for movement to the case-packing area. Empty filler flats and cartons are obtained from overhead chutes at each tray. The carton and filler-flat chutes are loaded periodically by the packagers from a supply in the package-material storage area.

Automatic Packaging and Supplying Packaging Material.—Machine tending refers to those operations required when automatic packaging is incorporated into the system. It includes manually packaging small quantities of eggs in the size classes not packaged automatically. One machine tender is required for each two basic-equipment units. When the third equipment unit is added, an additional machine tender is needed. With two workers and three equipment units, each worker would be responsible for 1½ equipment units.

The machine tender is stationed within the immediate vicinity of the automatic packers J. He observes the operation of the automatic packers at all times and immediately corrects situations that cause machine stoppages. He obtains bundles of cartons and filler flats from the package-material storage area and loads the packaging-material dispenser chutes as needed. Each carton dispenser has a capacity of approximately 125 cartons.

At intervals, the machine tender walks to the manual-packing trays G, H, and I and transfers eggs to filler flats obtained from overhead chutes at each packaging station. Filled filler flats of eggs are pushed onto the package conveyor K for movement to the case-packing area.

In the automatic packers, the eggs are automatically oriented so that they will be placed small-end down in the package. Six eggs at a time are picked up by the six vacuum cups on the packing head and placed into six empty cells of a carton on an indexing conveyor below. The indexing conveyor controls the movement of the cartons so that six empty cells will always be in position to receive the next six eggs. The conveyor moves filled cartons onto an inclined belt that moves them onto the package conveyor K.

Packing Cases.—The case-packing equipment and the work of the case packer are the same as described in system A. However, in system B, the floorman seals all the cases and places them on pallets for the three-unit operation.

Production Rates and Labor Requirements

The average output of 1 basic-equipment unit, when operated at capacity in a commercial operation handling eggs of 90 percent A quality, is 17.32

cases per hour for both all-manual and combined automatic and manual packaging (table 3). The synthesized operations for 2- and 3-equipment units have capacities of 34.64 and 51.96 cases per hour, respectively. The elapsed time to grade and pack 100 cases of eggs is 5.76, 2.88, and 1.92 hours with the 1-, 2-, and 3-equipment units, respectively. Annual production capacities are 34,640, 69,280, and 103,920 cases, respectively, for these equipment units.

With all-manual packaging, the total labor required to grade and pack 100 cases of eggs is 23.37, 20.49, and 19.99 man-hours, respectively, for 1-, 2-, and 3-equipment units (table 4).

With combined automatic and manual packaging, the total labor required to grade and pack 100 cases of eggs is 17.61, 11.85, and 12.31 man-hours, respectively, for 1-, 2-, and 3-equipment units. The most effective equipment combination occurs at the two-unit level, because only one machine tender is required and his time is almost fully utilized. Although it would appear that one machine tender could tend three units under ideal operating conditions, malfunction of three units or of units one and three at the same time could result in a failure of immediate attention because of walk time between service points.

Egg-Grading and Packing Costs

The labor and equipment costs for grading and packing 100 cases of eggs with 1-, 2-, and 3-equipment units of system B in an all-manual packaging operation and a combined automatic- and manual-packaging operation are shown in table 3.

In each operation size, equipment costs are greater but labor costs are less with automatic packaging. With 1-equipment unit, for example, the $10.08 reduction in labor cost per 100 cases more than offsets the $6.63 increase in equipment cost. The net saving is $3.45 per 100 cases, or approximately $0.03 per case. With 2-equipment units, a net saving of $8.43 per 100 cases, or approximately $0.08 per case, can be realized with automatic packaging. A net saving of $6.76 per 100 cases, or approximately $0.07 per case, can be realized with automatic packaging when 3-equipment units are used.

System C

System C provides for mass candling; mechanized sizing, line loading, and inventorying; and automatic packaging of all shell egg-weight classes. The basic-equipment unit provides for the complete grading and packing operation, including closing and sealing cartons and packing cases. The infeed and candling conveyors operate at the rate of 35 cases (12,600 eggs) per hour.

Operations consisting of 1- and 2-equipment units (35 and 70 cases per hour) were synthesized. The two-equipment units are operated independently of each other, except that one floorman supplies both units. The equipment layout and location of the workers are shown in figure 10. At the two-unit production level, this system requires approximately 2,400 square feet of floor space.

The major components of system C are conveyors to supply cases of ungraded eggs, an infeed

TABLE 3.—*System B (mass candling; all-manual or combined automatic and manual packaging): Production rates and labor and equipment costs to grade and pack 100 cases of eggs with 1-, 2-, and 3-equipment units*

Operation and equipment units	Crew size	Elapsed time per 100 cases	Production [1]		Cost per 100 cases		
			Per hour	Per year (2,000 hours' operation)	Labor [2]	Equipment [3]	Total
All-manual packaging:	*Workers*	*Hours*	*Cases*	*Cases*	*Dollars*	*Dollars*	*Dollars*
1	5	5.76	17.32	34,640	40.90	8.88	49.78
2	8	2.88	34.64	69,280	35.86	8.09	43.95
3	11	1.92	51.96	103,920	34.98	7.91	42.89
Combined automatic and manual packaging:							
1	4	5.76	17.32	34,640	30.82	15.51	46.33
2	5	2.88	34.64	69,280	20.74	14.78	35.52
3	7	1.92	51.96	103,920	21.54	14.59	36.13

[1] Based on hourly production rate of 17.32 cases per equipment unit.

[2] Based on labor requirements in table 4 and wage rate of $1.75 per hour.

[3] Based on total hourly equipment costs given in appendix tables 13–18. All equipment is assumed to be operating during entire elapsed time. Equipment costs are based on total annual production.

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TABLE 4.—*System B (mass candling; all-manual or combined automatic and manual packaging): Labor required to grade and pack 100 cases of eggs with 1-, 2-, and 3-equipment units*

Equipment units, elapsed time, and type of worker	All-manual packaging				Combined automatic and manual packaging			
	Workers required	Labor required			Workers required	Labor required		
		Productive	Unproductive	Total		Productive	Unproductive	Total
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*
1 unit, 5.76 hours:								
Floorman	1	0.33	(1)	0.33	1	0.33	(1)	0.33
Loader-candler	1	5.00	0.76	5.76	1	5.00	0.76	5.76
Packager or machine tender [2]	2	9.62	1.90	11.52	1	5.76	(3)	5.76
Case packer	1	2.04	3.72	5.76	1	2.04	3.72	5.76
Total	5	16.99	6.38	23.37	4	13.13	4.48	17.61
2 units, 2.88 hours:								
Floorman	1	.33	(1)	.33	1	.33	(1)	.33
Loader-candler	2	5.00	.76	5.76	2	5.00	.76	5.76
Packager or machine tender [2]	4	9.62	1.90	11.52	1	2.88	(3)	2.88
Case packer	1	2.04	.84	2.88	1	2.04	.84	2.88
Total	8	16.99	3.50	20.49	5	10.25	1.60	11.85
3 units, 1.92 hours:								
Floorman	1	.79	(1)	.79	1	.79	(1)	.79
Loader-candler	3	5.00	.76	5.76	3	5.00	.76	5.76
Packager or machine tender [2]	6	9.62	1.90	11.52	2	3.84	(3)	3.84
Case packer	1	1.65	.27	1.92	1	1.65	.27	1.92
Total	11	17.06	2.93	19.99	7	11.28	1.03	12.31

[1] No unproductive labor is charged to floorman, because he is available for other plant work.

[2] In all-manual packaging operation, this worker packages all 6 weight classes of eggs; in combined automatic and manual packaging, this worker tends automatic packers for 3 principal weight classes and packages 3 less frequently occurring weight classes.

[3] Machine tender is considered productive during entire elapsed time, because he must be in immediate vicinity while automatic packers are operating.

conveyor for filler flats of eggs, a candling conveyor, an automatic lifter that removes eggs from filler flats and places them on the candling conveyor (mechanized line loading), an in-line sizer, electrical counters that operate in conjunction with the sizer, automatic packers, a memory unit, a package conveyor, a conveyor for empty cases, and a case-sealing station. Other equipment will be discussed in the description of operations and product flow.

Four workers are required to operate one-equipment unit at capacity, and seven are required to operate two units. A loader-tender, a candler, and a case packer are required for each unit; one floorman is needed for either the one- or two-unit operation.

Description of Operations and Product Flow

Supplying Cases of Ungraded Eggs.—The floorman brings pallet loads of cases of ungraded eggs to the line, as described for systems A and B. He places the pallets at the end of conveyor A_1 and transfers cases to the conveyor. The conveyor has a capacity of 10 cases.

Supplying Eggs and Machine Tending.—The loader-tender transfers cases of eggs from conveyor A_1 to conveyor A_2. He opens cases, removes the two top flats, and stacks them on the shelf above conveyor B. He places one filler flat of eggs at a time in single file on infeed conveyor B. This conveyor has a capacity of 11 filler flats of eggs when fully loaded. The loader-tender removes leaker eggs from filler flats on the conveyor, placing them in trays on the shelf above. He places empty cases on the overhead conveyor O for movement to the case-packing area.

Infeed conveyor B indexes one filler flat of eggs at a time toward the automatic lifter C. This 30-cup vacuum lifter picks up the 30 eggs in the filler flat and places them on the candling conveyor E. The emptied filler flat is automatically stacked in the accumulator D as the next filler flat of eggs

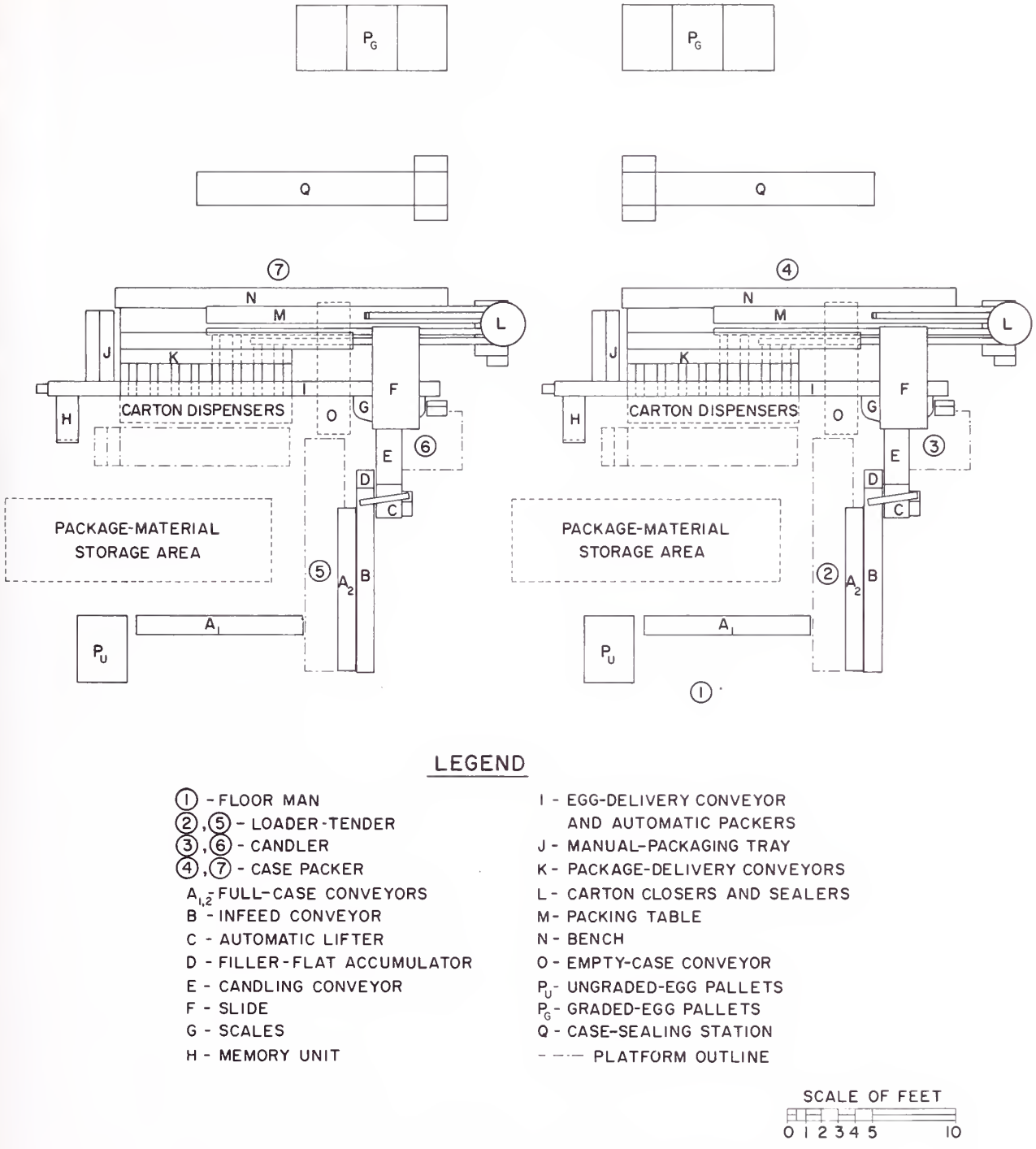

FIGURE 10.—Layout of equipment for egg-grading and packing operation in system C.

advances. The filler-flat accumulator will hold approximately 100 empty filler flats. The shelf above conveyor *B* also provides space for empty filler flats.

Periodically the loader-tender removes the empty filler flats from accumulator *D* and the shelf and places them on the floor beside conveyor A_2. He also places leaker trays here.[8]

The loader-tender also supplies cartons and filler flats to the dispensers of the automatic-pack-

[8] See footnote 6, p. 8.

aging machines and performs the general function of machine tending. He must be in the immediate vicinity when the equipment is operating.

Candling, Sizing, and Inventorying.—The automatic lifter *C* places eggs in six-abreast formation on the candling conveyor *E*. The movement of the candling conveyor is synchronized with that of the automatic lifter. The candler examines eggs for blind checks and interior defects as they move over the underlit area of the candling conveyor. He removes undergrade eggs and places them in filler flats on slide *F*. The slide slopes toward the packing table *M*. As filler flats of undergrade eggs accumulate, the candler pushes them to the incline and they then move by gravity to the packing area.

The in-line sizing equipment *G* consists of a moving cup conveyor and two automatic weighing stations or sets of scales. One row of six eggs at a time moves off the candling conveyor *E* into the individual egg cups of the conveyor. The cups are designed to transport the eggs in a position that will insure packaging small-end down. The eggs are moved to the weighing stations and the weight of each egg within the six shell egg-weight classifications is automatically determined. After weighing, the eggs are released small-end down into empty cups of the egg-delivery conveyor *I*.

Electrical counters operate in conjunction with the scales. Each egg is automatically recorded by the counter for its size class as its weight is determined. Pushbutton counters are provided for each classification of undergrade eggs. The candler pushes the counter button when he removes undergrades from conveyor *E*. At the end of a producer lot, the total number of eggs of each quality and size class has been recorded by the counters. The candler inserts the producer ticket for the lot into the counter control box and depresses the printing lever. The egg count for each quality and size class and a total egg count for the lot are automatically printed on the producer ticket, and the counters are cleared for the next producer lot.

The candler takes inventory at the end of each producer lot. Two filler-flat spaces are left vacant on the infeed conveyor *B* between lots, resulting in 10 empty rows on the candling conveyor *E* between lots. This practice is required to insure an accurate inventory before the counters begin tallying the eggs in the next lot.

Packaging.—Eggs are released into individual cups of the egg-delivery conveyor *I* after they are weighed. Conveyor *I* moves the eggs single file directly over the packaging stations. The memory unit *H* controls the packaging of the eggs into the cartons or filler flats for their respective size classes. The memory unit "remembers" which conveyor cup is carrying each egg. As each egg reaches the packaging station for its size class, a selector switch opens the cup and allows the egg to fall small-end down into the correct empty cell of the carton or filler flat underneath. When a carton or filler flat is filled, it is automatically moved from under conveyor *I* to the package conveyor *K* and replaced with an empty carton or filler flat from the dispenser. The loader-tender keeps the packaging-materials dispensers filled with cartons and filler flats. Carton and filler-flat dispensers have a capacity of 50 each.

The manual-packaging tray *J* is a safety feature of the system. If for any reason an egg is not released at its correct packaging station, it is delivered to the packaging tray *J* at the end of the conveyor. These eggs may be packed in filler flats and rerun through the machine or sold as ungraded.

Package-delivery conveyor *K* moves filler flats and cartons of eggs from the packaging stations to the packing table *M*. Filler flats of eggs move directly onto the left side of the packing table. Cartons of eggs are moved to the carton closer and sealer *L*. They are turned 90 degrees at the end of conveyor *K* and routed through the closer *L*. After the cartons have been closed and dated, they are turned 90 degrees and automatically moved onto table *M* from the right.

Packing Cases.—The case packer packs cartons and filler flats of eggs into cases on bench *N*, including the filler flats of undergrades from slide *F*. He packs eggs that accumulate in the manual-packing tray *J* into filler flats on a shelf above the tray. A day's supply of empty filler flats is stored on the floor adjacent to the tray.

The case packer transfers filled cases to the wheel conveyor of the case-sealing station *Q*. This conveyor has a capacity of 15 cases. He seals the cases and places them on the graded-egg pallet P_G for their particular order.

Production Rates and Labor Requirements

The average output that can be expected from one 35-case-per-hour equipment unit is 30 cases per hour when operated at capacity in a commercial operation handling eggs of 90 percent A quality (table 5). The synthesized operation of 2-equipment units has a capacity of 60 cases per hour. Annual capacity of 1-equipment unit is 60,000 cases and of 2-equipment units 120,000 cases. The elapsed time required to grade and pack 100 cases of eggs with 1 and 2 units of system C is 3.38 and 1.69 hours, respectively.

The total labor required to grade and pack 100 cases of eggs with 1- or 2-equipment units of system C is 10.46 man-hours (table 6). The total labor requirements are identical for the one- and two-unit operations, because there is no change in the utilization of labor when the second unit is included.

TABLE 5.—*System C (mass candling and automatic packaging): Production rates and labor and equipment costs to grade and pack 100 cases of eggs with 1- and 2-equipment units*

Equipment units	Crew size	Elapsed time per 100 cases	Production [1]		Cost per 100 cases		
			Per hour	Per year (2,000 hours' operation)	Labor [2]	Equipment [3]	Total
	Workers	*Hours*	*Cases*	*Cases*	*Dollars*	*Dollars*	*Dollars*
1	4	3. 38	30	60, 000	18. 31	23. 69	42. 00
2	7	1. 69	60	120, 000	18. 31	23. 69	42. 00

[1] Based on hourly production rate of 30 cases per equipment unit.

[2] Based on labor requirements in table 6 and wage rate of $1.75 per hour.

[3] Based on total hourly equipment costs given in appendix tables 19 and 20. All equipment is assumed to be operating during entire elapsed time. Equipment costs are based on total annual production.

TABLE 6.—*System C (mass candling and automatic packaging): Labor required to grade and pack 100 cases of eggs with 1- and 2-equipment units*

Equipment units, elapsed time, and type of worker	Workers required	Labor required		
		Productive	Unproductive	Total
	Number	*Man-hours*	*Man-hours*	*Man-hours*
1 unit, 3.38 hours:				
Floorman	1	0. 32	(1)	0. 32
Loader-tender	1	3. 38	(2)	3. 38
Candler	1	2. 88	0. 50	3. 38
Case packer	1	2. 11	1. 27	3. 38
Total	4	8. 69	1. 77	10. 46
2 units, 1.69 hours:				
Floorman	1	. 32	(1)	. 32
Loader-tender	2	3. 38	(2)	3. 38
Candler	2	2. 88	. 50	3. 38
Case packer	2	2. 11	1. 27	3. 38
Total	7	8. 69	1. 77	10. 46

[1] No unproductive labor is charged to floorman, because he is available for other plant work.

[2] Loader-tender is considered productive during entire elapsed time, because he must be in immediate vicinity when equipment is operating.

Egg-Grading and Packing Costs

The basic-equipment unit of system C is not available for purchase, but is contracted on a 5-year rental basis. The labor and equipment costs to grade and pack 100 cases of eggs with 1 and 2 units of system C are shown in table 5.

The labor and equipment costs per 100 cases are identical for the 1- and 2-unit operations, because the production rate is doubled when the second basic-equipment unit is added. Each machine is a self-contained production unit. There is no change in labor or equipment utilization per 100 cases when the second unit is added.

System D

System D provides for mass candling, mechanized sizing and inventorying, and automatic packaging of from two to five of the shell egg-weight classes. The basic-equipment unit includes an infeed candler that operates at the rate of 60 cases (21,600 eggs) per hour and from 2 to 5 packing machines. Each packing machine operates at the rate of 30 cases per hour. The 60-case-per-hour production rate is within the same volume range as 6 units of system A, the 3 units of system B, and 2 units of system C, justifying a reasonable comparison of systems within the limits of the

equipment combinations and operating situations described in this report.

The basic components of system D are a conveyor for cases of ungraded eggs, the infeed candler, an in-line sizer, electrical counters that operate in conjunction with the sizer, automatic-packing machines, manual-packing trays, a package conveyor, carton closers and sealers, a conveyor for empty cases, and case-packing equipment. The equipment layout is shown in figure 11. The system occupies approximately 2,400 square feet of floor space.

In the operation described in this report, five automatic packers are used for four egg classes—extra large, large, medium, and small eggs. The extra machine is used for large or medium eggs, depending on which size predominates in the eggs being run. It could also be used to package eggs of one size class in two types of packaging material simultaneously.

To operate the equipment at capacity, a crew of six workers is required: One loader, two candlers, one machine tender, one case packer, and a floorman. The crew members are shown diagrammatically at their respective work stations on the equipment layout (fig. 11).

Description of Operations and Product Flow

Supplying Cases of Ungraded Eggs.—The conveyor system *A* for cases of ungraded eggs consists of a 10-foot straight section and a 90-degree curved section of 24-inch gravity-roller conveyor, and an 11½-foot inclined 24-inch belt conveyor. The conveyor begins in the cooler or storage area. It holds 30 cases or the equivalent of 1 pallet load of eggs when fully loaded.

The floorman transports pallet loads of ungraded eggs to the end of the conveyor, transfers one case at a time to the conveyor, and unlocks the case flaps. The cases move by gravity to the inclined belt section of the conveyor. The loader notifies the floorman when the conveyor needs to be reloaded with eggs.

Supplying Eggs.—The loader controls movement of cases up the inclined belt and onto dead plate *B* by a pedal-operated switch underneath the dead plate. When a case reaches the dead plate, the loader turns down the case flaps, moves the top filler flat on one side of the case to the adjacent side, and transfers the exposed eggs to infeed candler *E*, 30 at a time, with a vacuum lifter, in the same manner as described in system A. Empty filler flats are stacked on shelf C_1 and empty cases are placed on the overhead empty-case conveyor *D* for movement to the case-packing area. The empty-case conveyor is a 12-inch wheel-type gravity conveyor.

The infeed candler *E* is a roller-type conveyor capable of transporting 12 eggs abreast. The first 3 feet of the conveyor, the loading section, is illuminated from above.

The loader examines the eggs as they advance 12 abreast on the infeed conveyor, removes leakers, and places them in leaker trays on shelf C_2. Periodically when the loader is caught up or the machine stopped, he places empty filler flats from shelf C_1 and the leaker trays from shelf C_2 on the floor behind him for pickup by other workers.[9]

Candling.—The eggs advance 12 abreast to the candling section of the infeed candler *E*. Each row of 12 eggs is stopped and spun seven times while passing over the underlighted section.

Two workers are required to candle the eggs when the equipment is operated at capacity. One candler stands on each side of the infeed candler at the underlit area. The candlers examine the eggs for blind checks and interior defects as they advance and spin over the area illuminated from below. They remove undergrade eggs and place them on belt *G* or in filler flats on shelf *F*. Belt *G* moves the eggs to the undergrade packing tray *H*.

Belt *G* and packing tray *H* are divided into three sections by metal partitions to provide for three classes of undergrade eggs. The channels formed by the dividers guide the eggs of each classification to separate sections of the packing tray. Shelf *F* provides space for filler flats for accumulating eggs of additional undergrade classifications.

As filler flats of undergrades accumulate on shelf *F*, candler (3) transfers them to the shelf at the undergrade-packing tray *H*. The machine tender places them on the package-delivery conveyor *N* for movement to the case-packing area.

Sizing and Inventorying.—The eggs are moved from the infeed candler *E* onto the scales *I*. The scales consist of 5 banks of 12 individual egg scales, 6 pickup bars, and 6 takeaway belts. The five banks of scales are adjusted to respond to the minimum weight of the jumbo, extra large, large, medium, and small egg-weight classes. There is one takeaway belt for each of the six size classes. There are no scales for peewee eggs. All eggs not ejected from the last bank of scales (adjusted for small eggs) are placed directly onto the takeaway belt for peewee eggs.

As each row of 12 eggs moves from the infeed candler *E*, it is stopped momentarily. The first pickup bar picks up the 12 eggs and places them on the first bank of scales and continues in an arc to pick up the next row of eggs as they leave the conveyor. The eggs heavier than the first-scale adjustment (jumbo) are ejected onto the takeaway belt for that size class and moved to the egg-delivery belt *J*.

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[9] See footnote 6, p. 8.

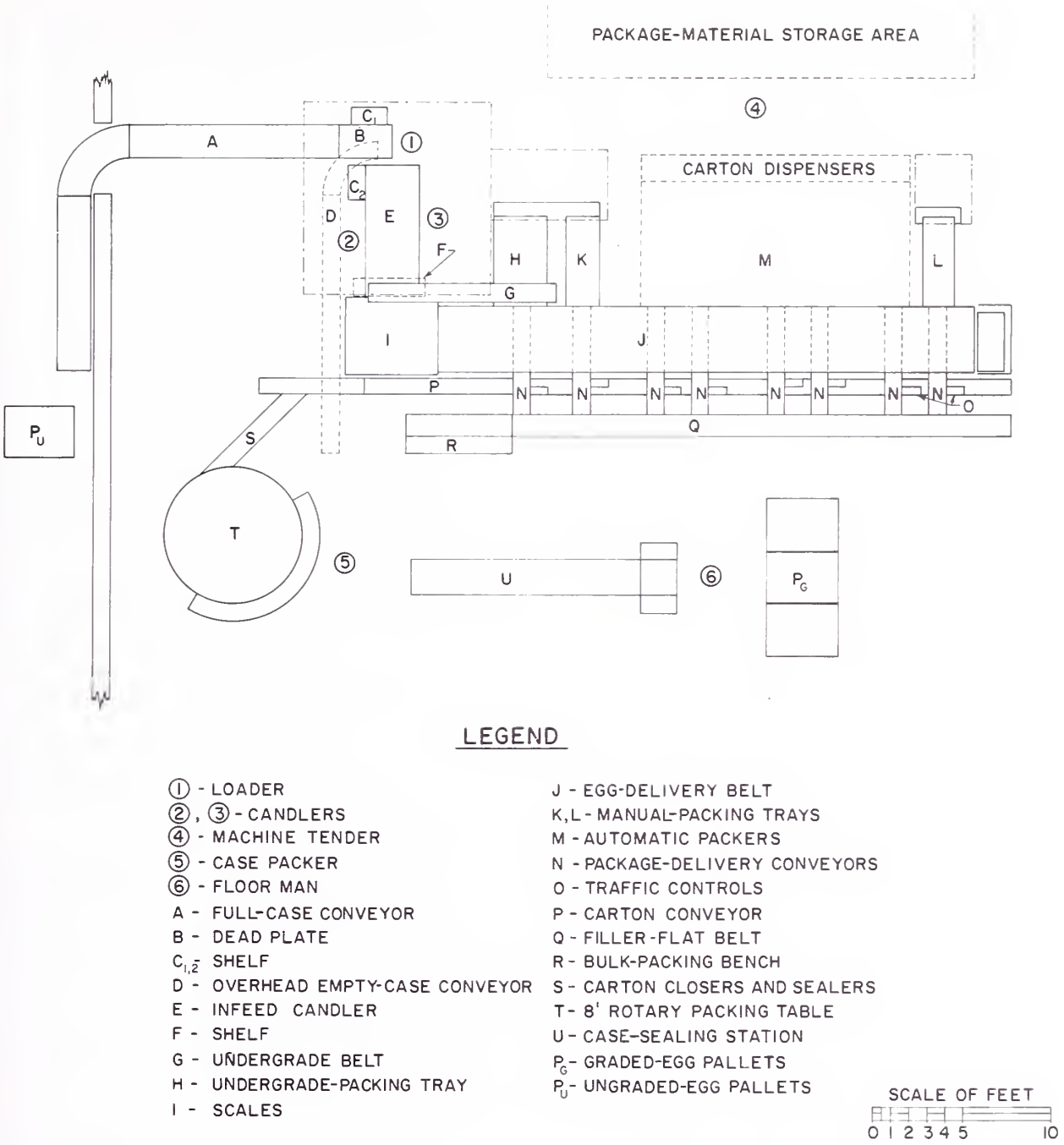

FIGURE 11.—Layout of equipment for egg-grading and packing operation in system D.

The six pickup bars operate in unison. As the first bar picks up the next row of 12 eggs leaving the infeed candler, the second pickup bar picks up the eggs that were not ejected from the first bank of scales and moves them on to the second bank of scales. The lightest eggs pass over five scale banks.

The takeaway belts move the eggs to the egg-delivery belt *J*, which is divided into six channels. The channels are formed by wooden dividers that guide the eggs of each weight class to their respective automatic- or manual-packing stations.

The inventorying equipment for system D consists of a series of electrical counters connected

with the sizer. Eggs of each size class are automatically recorded as they move from the scale *I* to the egg-delivery belt *J*. Each egg trips a microswitch and is recorded in the counter control box. In the same manner, the three classifications of undergrades placed on the undergrade belt *G* trip switches and are counted in route to undergrade-packing tray *H*. The count of undergrades placed in filler flats or leaker trays on shelves *F* or C_2 is also recorded in the control box. The loader and candlers use pushbuttons as they place the undergrades into containers.

Six rollers are left vacant on the infeed candler between producer lots. When the counters stop tabulating the egg count, the candlers take inventory. The egg count of each quality and size class on which producers are paid has been recorded in the counter control box. Candler (2) inserts the producer ticket into the counter control box and depresses the printing lever. The quality and size-class count is printed on the producer ticket, and the counter is cleared for the next producer lot.

Packaging.—The synthesized operation of system D provides for the automatic packaging of extra large, large, medium, and small eggs. The eggs of these size classes are diverted from the egg-delivery belt *J* onto the belt of the reservoir tray of the automatic packer *M* for their size class.

Jumbo and peewee eggs are guided off the egg-delivery belt *J* to crossfeed belts that deliver them to the manual-packing trays *K* and *L*, respectively.

The machine tender, stationed within the immediate vicinity of the automatic packers, continuously observes the operation of the automatic packers and also packages jumbo, peewee, and undergrade eggs at manual-packing trays *H*, *K*, and *L*. The general machine-tending function is the primary duty of the machine tender. When an automatic packer malfunctions, the machine tender goes immediately to the packer, takes the necessary corrective action, and restarts the packer.

Reservoir trays in the automatic packers permit accumulation of eggs during periods when the machines are stopped for any reason. Thus, the remainder of the line can continue to run while action is being taken to restart an automatic packer. If downtime exceeds the length of time required to fill the reservoir tray, the line is stopped.

The eggs in automatic packers are moved by the belt in the reservoir trays to the ends of the trays. At the end of the reservoir, they move into the accumulator of the automatic packer. When six eggs are in the accumulator, the packaging mechanism is activated, and the eggs are released small-end down into six clamshell-type cups of the packaging mechanism and lowered to a release position close to the top of a carton or filler flat. At the end of the lowering cycle, a cam trips a release and the six eggs are placed small-end down into the six empty cells of a container underneath. The position of the container is controlled by an indexing device synchronized with the packaging mechanism so that six empty cells of a carton or filler flat, released from an automatic carton dispenser, are always in position to receive the next six eggs being packaged. Filled cartons are moved onto the package-delivery conveyor *N*.

Periodically the machine tender walks to the manual-packing trays *H*, *K*, and *L* and packages eggs that have accumulated into filler flats. Empty filler flats are obtained from overhead chutes at each packing tray. The chutes are loaded by the machine tender with filler flats obtained from the package-material storage area. When a filler flat is filled with eggs, it is placed on the package-delivery conveyor *N* for movement to the packing area.

The machine tender obtains bundles of cartons from the package-material storage area and places them on the floor behind the automatic packer in which they will be used. He opens the bundles and periodically loads the carton dispensers for the automatic packers.

The package-delivery conveyor *N* moves filled cartons of eggs from the automatic packers underneath the egg-delivery belt *J* and guides them into the carton chutes *O*. The cartons move by gravity down the chutes onto the carton conveyor *P* below. When a carton of eggs is sliding down a chute, any approaching cartons on the belt in its direct path are stopped until the carton is discharged onto the carton conveyor *P*. Filler flats of eggs placed on the package-delivery conveyor *N* move underneath the egg-delivery belt *J* and onto the filler-flat belt *Q*.

Packing Cases.—Cartons of graded eggs are moved by the carton conveyor *P* to the case-packing area. At the end of the carton conveyor, the cartons of eggs are guided through the closers and sealers *S* onto the 8-foot rotary packing table *T* for packing in cases. Filler flats of graded eggs are moved to the case-packing area by the filler-flat belt *Q*. The filler flats of eggs move to the end of the belt and onto the bulk-packing bench *R*. The bench has a capacity of six filler flats of eggs.

The case packer removes cartons of eggs from the rotary packing table *T*, two at a time, and packs them into cases on a bench that partly encircles the packing table. When six filler flats of eggs accumulate on the bulk-packing bench *R*, the case packer walks to the bench and packs them one at a time into cases. Empty cases are obtained from the overhead empty-case conveyor *D*. As cases are filled, they are closed and transferred to the 24-inch gravity-wheel conveyor of the case-sealing station *U*.

TABLE 7.—*System D (mass candling; automatic packaging of 4 egg classes with 5 machines): Production rates and labor and equipment costs to grade and pack 100 cases of shell eggs with 1-equipment unit*

Crew size	Elapsed time per 100 cases	Production [1]		Cost per 100 cases		
		Per hour	Per year (2,000 hours' operation)	Labor [2]	Equipment [3]	Total
	Hours	*Cases*	*Cases*	*Dollars*	*Dollars*	*Dollars*
6 workers	1. 92	52. 18	104, 360	18. 17	10. 51	28. 68

[1] Based on hourly production rate of 52.18 cases.
[2] Based on labor requirements in table 8 and wage rate of $1.75 per hour.
[3] All equipment is assumed to be operating during entire elapsed time. Hourly equipment costs are given in appendix table 21. Equipment costs are based on total annual production.

TABLE 8.—*System D (mass candling; automatic packaging of 4 egg classes with 5 machines): Labor required to grade and pack 100 cases of eggs with 1-equipment unit*

Equipment unit, elapsed time, and type of worker	Workers required	Labor required		
		Productive	Unproductive	Total
1 unit, 1.92 hours:	*Number*	*Man-hours*	*Man-hours*	*Man-hours*
Floorman	1	0. 78	[1]	0. 78
Loader	1	1. 75	0. 17	1. 92
Candler	2	3. 34	. 50	3. 84
Machine tender	1	1. 92	[2]	1. 92
Case packer	1	1. 65	. 27	1. 92
Total	6	9. 44	. 94	10. 38

[1] No unproductive labor is charged to floorman, because he is available for other plant work.
[2] Machine tender is considered productive during entire elapsed time, because he must be in immediate vicinity while automatic packers are operating.

The cases of graded eggs accumulate at the case-sealing station. Periodically the floorman walks to the case-sealing station and seals the cases. After the cases are sealed, they are transferred to the graded-egg pallet P_G for their particular order or stock supply.

Production Rates and Labor Requirements

The average output that can be expected from the 60-case-per-hour equipment unit of system D is 52.18 cases per hour when operated at capacity in a commercial operation handling eggs that are 90 percent A quality (table 7). Annual capacity of the system is 104,360 cases. Based on the average hourly production of 52.18 cases, the elapsed time to grade and pack 100 cases of eggs with system D is 1.92 hours.

The total labor required to grade and pack 100 cases of eggs with system D is 10.38 man-hours (table 8).

Egg-Grading and Packing Costs

The labor and equipment costs to grade and pack 100 cases of eggs with the synthesized operation of system D are shown in table 7.

COMPARISON OF SYSTEMS

All the equipment for the egg-grading and packing systems studied can be utilized on more than one shift. The labor wage rate varies between plants and different sections of the country. These factors have an important effect on egg-grading and packing costs and tend to restrict the applicability of the cost data to 2,000 hours' annual operation.

On the limited basis of comparable annual production rates, system B (1 and 2 units, combined automatic and manual packaging) excelled at production levels of approximately 35,000 and 70,000

cases per year (table 3) and system D [10] at approximately 104,000 cases per year (table 7). It should be noted, however, that at all levels of production, system A was lowest in equipment costs. If egg quality or daily receipts were irregular, unit costs of the more mechanized systems would rise rapidly because the more costly equipment could not be fully utilized. Labor and equipment costs for system C are constant for the one and two units (table 5), because each unit is a self-contained system, and the equipment cost figure is derived from a lease rate based on cases per hour.

PROCEDURE FOR ESTIMATING GRADING AND PACKING COSTS

In order to avoid restricting the values derived from this study to the limited basis of comparable annual production rates and labor and equipment costs as given (tables 1, 3, 5, and 7), a method of estimating the grading and packing costs for each system for annual operating levels and labor wage rates other than those used in this study was developed. Annual equipment ownership costs, the factor with the least degree of variability and effect on total cost, were assumed to be constant. The procedure permits using any labor wage rate in estimating the grading and packing costs and widens the range of applicability of the data.

The general equation for estimating the cost per case to grade and pack a specified volume of eggs annually with a particular equipment type is—

$$\text{Cost per case}=\frac{\left[\begin{array}{r}\text{annual equipment ownership costs}\\ +\text{annual equipment operating}\\ \text{costs}+\text{annual labor cost}\end{array}\right]}{\text{number of cases per year}}$$

or

$$\text{Cost per case}=\frac{A+(T\times E)+(T\times L\times R)}{T\times P}$$

Where:

Cost per case = labor and equipment costs per case (dollars)
A = annual equipment ownership costs (dollars)
T = number of hours equipment is operated annually (machine-hours)
E = hourly equipment operating costs (dollars per machine-hour)
L = labor required per hour operated (man-hours per hour of operation)
R = average hourly labor wage rate of all crew members (dollars per hour)
P = hourly production rate of equipment (cases per hour)

The annual equipment ownership cost (A) is the only term of the equation that does not vary directly with the number of hours the equipment is operated annually. It consists of depreciation, interest, insurance, taxes, and rent. These are fixed costs, in that they are present regardless of the number of hours the equipment is operated annually.

[10] System D was not considered for lower volume levels because of incomplete utilization of crew and equipment.

Depreciation costs were estimated by prorating the initial cost of each item of equipment over its expected life based on 2,000 hours' annual use. Depreciation costs are dependent to a degree on the hours operated annually, since this could affect the expected life of the equipment. However, since the assumed expected life was based on a compromise between depreciation and obsolescence, the effect on the equipment ownership costs would be minimized under an effective preventive maintenance program. The annual equipment ownership costs were therefore assumed to be constant for each equipment type for a volume range equivalent to 1,500 to 4,000 hours' annual operation. This permits evaluating each equipment type at any operating level within a range equivalent to a one- or two-shift operation.

Given the average hourly labor wage rate, the cost per case to grade and pack a specified volume of eggs annually with each of the synthesized operations can be computed from the data in table 9 and equation (a) for systems A, B, and D and equation (b) for system C.

$$(a)\quad \text{Cost per case}=\frac{A+(T\times E)+(T\times L\times R)}{N}$$

Where:

$N=T\times P$, or number of cases per year

$$(b)\quad \text{Cost per case}=\frac{\left[\begin{array}{r}A+(T_1\times E_1)+(T_2\times E_2)\\ +(T\times L\times R)\end{array}\right]}{N}$$

Where:

T_1 = number of machine-hours between 1,500 and 2,000 that equipment is operated annually
T_2 = number of machine-hours between 2,001 and 4,000 that equipment is operated annually
E_1 = hourly equipment operating cost for each hour equipment is operated between 1,500 and 2,000 hours
E_2 = hourly equipment operating cost for each hour equipment is operated between 2,001 and 4,000 hours
$N=N_1$ (number of cases for hours of operation between 1,500 and 2,000) $+N_2$ (number of cases for hours of operation between 2,001 and 4,000)

TABLE 9.—*Production and cost data for egg-grading and packing systems studied*

Equipment description	Equipment annual volume range for operations of 1,500–4,000 hours	Average hourly production rate [1]	Annual equipment ownership costs [2]	Hourly equipment operating costs [3]	Labor required per machine-hour
(1)	(2)	(3)	(4)	(5)	(6)
System A (manual candling and packaging):	*Cases*	*Cases*	*Dollars*	*Dollars*	*Man-hours*
2 units	28, 500– 76, 000	19. 00	1, 860. 36	0. 20	6. 08
4 units	57, 000–152, 000	38. 00	3, 140. 85	. 36	11. 16
6 units	85, 500–228, 000	57. 00	4, 157. 37	. 52	16. 53
System B (mass candling; all-manual or combined automatic and manual packaging):					
All-manual packaging:					
1 unit	25, 980– 69, 280	17. 32	2, 399. 02	. 34	4. 06
2 units	51, 960–138, 560	34. 64	4, 315. 47	. 65	7. 11
3 units	77, 940–207, 840	51. 96	6, 310. 45	. 96	10. 41
Combined automatic and manual packaging (3 principal weight classes packaged automatically):					
1 unit	25, 980– 69, 280	17. 32	4, 302. 62	. 54	3. 06
2 units	51, 960–138, 560	34. 64	8, 122. 67	1. 07	4. 11
3 units	77, 940–207, 840	51. 96	12, 021. 22	1. 59	6. 41
System C (mass candling and automatic packaging):					
1 unit	[4] 45, 000– 60, 000	30. 00	[5] 13, 629. 59	[6] . 19	3. 09
	[7] 60, 001–120, 000			[8] 3. 49	
2 units	[4] 90, 000–120, 000	60. 00	[5] 27, 259. 01	[6] . 39	6. 18
	[7] 120, 001–240, 000			[8] 6. 99	
System D (mass candling; automatic packaging of 4 egg classes with 5 machines):					
1 unit	78, 270–208, 720	52. 18	8, 771. 70	1. 09	5. 36

[1] Rate expected under commercial operating conditions.
[2] Totals of column 7, appendix tables 10–21.
[3] Total operating costs, column 10, appendix tables 10–21, divided by 2,000 hours.
[4] Annual volume range for 1,500–2,000 hours' operation.
[5] Annual equipment ownership costs for 1– and 2–equipment units of system C include minimum annual rental of $13,200 per basic-equipment unit ($0.22 per case for first 60,000 cases), which is fixed cost, since it must be paid regardless of production; see also footnote 6.
[6] Maintenance of basic-equipment unit performed by company from which equipment is leased; see also footnote 5.
[7] Annual volume range for 2,001–4,000 hours' operation.
[8] Includes rental rate of $3.30 per hour per equipment unit ($0.11 per case × 30 cases per hour). This is a variable or operating cost (instead of an ownership cost) for production over 60,000 cases per equipment unit, because cost is dependent on number of cases produced.

The modified equation (*b*) is required for use with system C because the basic-equipment unit is leased rather than purchased. The minimum annual rental per equipment unit is $13,200, or 60,000 cases at $0.22 per case (the annual production for 2,000 hours' operation). This is an ownership or fixed cost, since it must be paid regardless of production. The rental rate for annual production over 60,000 cases (over 2,000 hours' use) is $0.11 per case per equipment unit. This is a variable or operating cost dependent on the number of cases graded.

Table 9 consolidates the production and cost data for each system. It gives the annual volume range, average hourly production rate, annual equipment ownership costs, hourly equipment operating costs, and labor required per hour of operation.

The procedure for computing the cost per case to grade and pack a specified volume of eggs annually with any of the synthesized operations is illustrated by the following examples:

Example 1.—Determine the cost per case to grade and pack 100,000 cases of eggs annually with four units of system A and three basic-equipment units of system B (combined automatic and manual packaging) at an average labor wage rate of $1.50 per hour.

Given: $N=100{,}000$ cases; $R=\$1.50$ per hour.

System A:

Step 1—Determine whether annual volume N is within annual volume range of equipment. Table 9, column 2, shows that 100,000 cases is within operating volume range of equipment.

Step 2—Determine number of machine-hours equipment must be operated to grade and pack N cases per year.

$$T=\frac{N}{P} \text{ (col. 3, table 9)}$$

$$T=\frac{100{,}000}{38}=2{,}632 \text{ hours}$$

Step 3—Determine unknowns in equation (*a*) (p. 24) for system from table 9.

A=$3,140.85 per year (col. 4)

E=$0.36 per hour (col. 5)

L=11.16 man-hours per hour (col. 6)

Step 4—Substitute values into equation (*a*) (p. 24) for system.

$$\text{Cost per case}=\frac{A+(T\times E)+(T\times L\times R)}{N}$$

$$=\frac{\left[\begin{matrix}3{,}140.85+(2{,}632\times 0.36)\\ +(2{,}632\times 11.16\times 1.50)\end{matrix}\right]}{100{,}000}$$

$$=\frac{3{,}140.85+947.52+44{,}059.68}{100{,}000}$$

$$=\frac{48{,}148.05}{100{,}000}$$

$$=\$0.481$$

System B:

Step 1—Determine whether annual volume N is within annual volume range of equipment. Table 9, column 2, shows that 100,000 cases is within operating volume range of equipment.

Step 2—Determine number of machine-hours equipment must be operated to grade and pack N cases per year.

$$T=\frac{N}{P} \text{ (col. 3, table 9)}$$

$$T=\frac{100{,}000}{51.96}=1{,}925 \text{ hours}$$

Step 3—Determine unknowns in equation (*a*) (p. 24) for system from table 9.

A=$12,021.22 per year (col. 4)

E=$1.59 per hour (col. 5)

L=6.41 man-hours per hour (col. 6)

Step 4—Substitute values into equation (*a*) (p. 24) for system.

$$\text{Cost per case}=\frac{A+(T\times E)+(T\times L\times R)}{N}$$

$$=\frac{\left[\begin{matrix}12{,}021.22+(1{,}925\times 1.59)\\ +(1{,}925\times 6.41\times 1.50)\end{matrix}\right]}{100{,}000}$$

$$=\frac{12{,}021.22+3{,}060.75+18{,}508.88}{100{,}000}$$

$$=\frac{33{,}590.85}{100{,}000}$$

$$=\$0.336$$

For these conditions, $0.145 per case could be saved if system B rather than system A were used. It should be noted that system A would have to be operated in excess of 2,000 hours per year to attain this production. This would involve a considerable amount of overtime or extra shifts. The availability of labor should be carefully considered in selecting which type equipment to use.

Example 2.—Determine the cost per case to grade and pack 200,000 cases of eggs annually with system C if the average labor wage rate is $1.25 per hour.

Given: N=200,000 cases; R=$1.25 per hour.

Step 1—Determine whether annual volume N is within annual volume range of equipment. Table 9, column 2, shows that 200,000 cases is in volume range for two basic-equipment units.

Step 2—Determine number of machine-hours equipment must be operated to grade and pack N cases per year.

Since there are two hourly equipment-operating cost rates for system C, the number of hours that the equipment must be operated at each rate must be determined. Table 9, column 2, shows that N, or 200,000 cases, is greater than the 120,000 cases of 2,000 hours' operation. The equipment must be operated for 2,000 hours to produce N_1 (120,000) cases; the number of cases beyond 120,000 then is represented as N_2.

$$T_1=\frac{N_1}{P}=\frac{120{,}000}{60}=2{,}000 \text{ hours}$$

$$N_2=N-N_1=200{,}000-120{,}000=80{,}000 \text{ cases}$$
(number of cases above 120,000)

$$T_2=\frac{N_2}{P}=\frac{80{,}000}{60}=1{,}333 \text{ hours}$$

$$T=T_1+T_2=2{,}000+1{,}333=3{,}333 \text{ hours}$$

Step 3—Determine unknowns in equation (*b*) (p. 24) for system from table 9.

A=$27,259.01 per year (col. 4)

E_1=$0.39 per hour (col. 5)

E_2=$6.99 per hour (col. 5)

L=6.18 man-hours per hour (col. 6)

Step 4—Substitute values into equation (*b*) (p. 24) for system.

$$\text{Cost per case}=\frac{\left[A+(T_1\times E_1)+(T_2\times E_2)+(T\times L\times R)\right]}{N}$$

$$=\frac{\left[27,259.01+(2,000\times 0.39)+(1,333\times 6.99)+(3,333\times 6.18\times 1.25)\right]}{200,000}$$

$$=\frac{\left[27,259.01+780+9,317.67+25,747.43\right]}{200,000}$$

$$=\frac{63,104.11}{200,000}$$

=$0.316 per case

These examples are only three illustrations of the application of the procedure to different situations. This procedure has an unlimited number of uses depending on the particular information desired. It permits determining the relative labor and equipment costs for grading and packing a specified volume of eggs annually with each equipment type under identical operating conditions. This procedure is an estimate, but it will serve as a guide in equipment selection and utilization if used as intended.

CONCLUSIONS

The selection of egg-grading and packing equipment is a major management decision. It generally represents a substantial capital investment and affects the profit and loss position of a company over a considerable period of time. If proper planning is exercised in the selection of equipment, significant savings can be realized.

Many types of egg-grading and packing equipment are available to the plant operator. There was no significant difference in the functions or quality of workmanship in the systems studied. The effectiveness or quality of workmanship is dependent on the proficiency of the employees operating the equipment and on the use of the equipment for the level of egg quality for which it was designed. All will do an effective job of grading and packing shell eggs if trained, proficient workers are employed, an effective preventive maintenance program is enforced, and use of the equipment is consistently confined to applicable levels of product quality.

Each type of equipment was designed for a specific purpose. Each offers certain advantages in different situations. It would be impossible to establish specific guidelines for the selection of equipment that would meet the needs of all situations encountered in an average commercial operation because of the many variables that can be involved. Each situation requires an evaluation on the basis of the needs of the particular plant. Findings in this study point out critical factors that should be considered when selecting an egg-grading and packing system. The study also illustrates a systems engineering approach to evaluating equipment and determining proper selection.

Equipment Capacity

The first step in selecting an egg-grading and packing system is to determine the required hourly, weekly, or annual production capacity. The present production capacity and the estimated production capacity at some future time should be determined as accurately as possible. The present requirement is usually known and should be the primary factor in determining the capacity of the system. The estimated future production capacity that will be required should also be considered. These production rates are imperative in order to select the right equipment and to utilize it effectively.

Type of Equipment

The general type of equipment that will be used must be determined after the capacity of the system is determined. This depends on many factors. The first decision is whether to use equipment that provides for manual or mass candling. This is determined primarily by the type of product that will be handled. If eggs are 90 percent A quality or better, equipment that provides for mass candling should be used. Automatic packaging should be considered. If the labor wage rate is moderately high, automatic-packaging equipment should be seriously considered. If automatic packaging is not indicated under existing conditions, equipment that provides for its ready adaptation should be selected.

Low or irregular egg quality requires equipment that incorporates manual candling. It should be

remembered that the highly mechanized systems were designed to handle large lots of uniformly fine-quality eggs and do not lend themselves to small lots of eggs of low or irregular quality. Manual-candling methods are costly, and every effort should be made to obtain eggs of high quality that lend themselves to more mechanized egg-grading and packing systems. A quality-control program, under which producers are paid a premium for large lots of uniformly fine-quality eggs, is one method of insuring this quality.

Some equipment that provides for manual candling is always needed. This equipment should be used for small lots of eggs of variable or irregular quality or for sample inspection to free the mechanized equipment for the product for which it was designed.

Select Alternatives

After the capacity of the system and the general type of equipment that will be used are determined, the specific type and amount of equipment must be selected. Usually several equipment types will serve the purpose. The required production capacity can usually be attained with a variable number of basic-equipment units, depending on the number of shifts the equipment will be operated. A good general policy is to select the smallest number of basic-equipment units possible and utilize them as much as possible. Processing costs per case decrease as equipment utilization increases.

All the equipment types that will serve the purpose should be considered. In established plants, change should be justified by provable economy.

A good procedure is to obtain a floor plan of the area of the plant in which the equipment will operate. Templates of all the equipment items should be obtained from equipment manufacturers or may be made from equipment specifications. The templates and the floor plan should be drawn to the same scale, and the templates arranged on the floor plan as the equipment will be placed. This will insure that the equipment can be laid out effectively in the space available. The layouts will present a good picture of how the equipment will look and operate when installed and will reveal bottlenecks at the planning stage. Operations consisting of all combinations of equipment should be synthesized so that all alternatives will be considered. This procedure will be time consuming, but will pay for itself many times if the right equipment is selected.

Compare Alternatives

Each of the synthesized operations should be evaluated. The labor and equipment costs to grade and pack the specified volume of eggs annually should be determined for each of the synthesized operations. Care should be exercised to insure that each operation is subjected to identical tests. Each alternative should be evaluated on the basis of the cost to the required job. If remodeling a facility is required for a certain type of equipment, the cost of remodeling should be included in the installation cost when comparing alternatives.

Decision

After all possible alternatives have been evaluated, the arrangement of equipment that will best meet the needs at the least cost should be selected. It is imperative that the decision be based on future as well as present conditions. It may be better to acquire excess capacity for the present in order to meet future needs at minimum cost. When planning to operate in excess of one shift, the availability of labor should be considered carefully. Flexibility should be a primary factor in the selection of an egg-grading and packing system.

GLOSSARY

Elapsed Time—Length of time in hours and fractions thereof from beginning to end of operation or cycle of operations.

Machine Downtime—Time that machine is idle because of malfunction or avoidable and unavoidable delays.

Producer Lot—Shipment of eggs from one producer.

Production Study—Technique for collecting operating and performance data on equipment by continuous observation for period of time under commercial operating conditions.

Productive Labor—Labor required to perform operation adjusted for fatigue and personal allowances.

Synthesized Operation—Theoretical model of egg-grading and packing operation consisting of basic and auxiliary equipment and labor that would be required under commercial operating conditions.

Template—Scale cutout of projected floor area occupied by machine.

Time Study—Procedure for determining

amount of time required for various components of a human activity by analyzing its individual elements as they are performed and determining time required for each with stopwatch.

Unproductive Labor—Labor potential that is idle under normal operating conditions while crew member(s) waits for other crew member(s) or machine(s) to complete operation cycle of job.

Unproductive Time—Idle time due to improper crew balance, undersupply of materials, machine breakdown, or any combination of these inherent to or normal in operation.

Work Sampling—Statistical technique for analyzing work to find allowances applicable to job, to determine machine utilization, and to establish standards of production.

APPENDIX

Equipment Costs

The equipment, ownership, and operating costs for each system were computed on the basis of the elapsed time required to grade and pack 100 cases of eggs (tables 10–21). The initial cost of each item of equipment was prorated over the expected life of the equipment at a rate of 2,000 hours' use per year. The expected life of each item of equipment was based on a compromise between depreciation due to wear and tear and obsolescence. The expected life for all the major items of equipment of each type was assumed to be 8.3 years. Spring-type and vacuum-type multiple egg lifters were assumed to have an expected life of 1 and 5 years, respectively. The interest, insurance, tax, and power rates were based on prevailing rates in industry. The rental rates for leased items of equipment were based on current prevailing rates.

Very few plants maintained accurate records of maintenance costs for each item of equipment. One plant maintained an accurate record of the maintenance costs for one type of equipment. It was assumed that the hourly maintenance cost for equipment would vary directly with the initial cost of the equipment. The maintenance cost per hour of operation per $1,000 initial cost of equipment was computed for the one plant for which data were available. The rate of $0.02 per hour per $1,000 initial cost was used for each equipment type.

Labor Costs

The hourly labor wage rate varies considerably between plants and sections of the United States. An assumed average labor wage rate of $1.75 per hour was used to determine the labor cost to grade and pack 100 cases of eggs with the synthesized operations of each system (tables 1, 3, 5, and 7). This included a base wage rate plus a prorated share of the cost of vacation pay, insurance, pensions, State unemployment compensation, FICA, workmen's compensation, and personal equipment.

TABLE 10.—*System A (manual candling): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 38,000 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
2 manual egg graders [6]	4, 707. 00	8. 3	567. 11	117. 68	188. 28		873. 07	[7] 28. 70	188. 27	216. 97	1, 090. 04
2 inventory systems, complete	1, 642. 00	8. 3	197. 83	41. 05	65. 68		304. 56	([8])	65. 67	65. 67	370. 23
2 carton racks	108. 00	8. 3	13. 01	2. 70	4. 32		20. 03		4. 33	4. 33	24. 36
1 package conveyor	930. 00	8. 3	112. 05	23. 25	37. 20		172. 50	8. 75	37. 18	45. 93	218. 43
1 empty-case conveyor	830. 27	8. 3	100. 03	20. 76	33. 21		154 00	8. 75	33. 19	41. 94	195. 94
1 bulk-packing bench	105. 00	8. 3	12. 65	2. 62	4. 20		19. 47		4. 19	4. 19	23. 66
1 case-sealing station	110. 53	8. 3	13. 32	2. 76	4. 42		20. 50		4. 43	4. 43	24. 93
1 spring lifter	19. 00	1. 0	19. 00	. 47	. 76		20. 23		. 74	. 74	20. 97
1 carton closer and sealer						192. 00	192. 00	7. 70	([9])	7. 70	199. 70
1 8-foot rotary packing table						84. 00	84. 00	5. 85	([9])	5. 85	89. 85
Total	8, 451. 80						1, 860. 36			397. 75	2, 258. 11

Total hourly equipment cost $1. 129

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes cost of 4 candling lights and auxiliary shelves and benches.
[7] Includes power cost for drive units, candling lights, and inventory system.
[8] Included in power cost of manual graders.
[9] Maintenance performed by company from which equipment is leased.

TABLE 11.—*System A (manual candling): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 76,000 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
4 manual egg graders [6]	9, 414. 00	8. 3	1, 134. 22	235. 35	376. 56		1, 746. 13	[7] 57. 40	376. 43	433. 83	2, 179. 96
4 inventory systems, complete	3, 284. 00	8. 3	395. 66	82. 10	131. 36		609. 12	([8])	131. 30	131. 30	740. 42
4 carton racks	216. 00	8. 3	26. 02	5. 40	8. 64		40. 06		8. 67	8. 67	48. 73
1 package conveyor	1, 098. 75	8. 3	132. 38	27. 47	43. 95		203. 80	17. 50	43. 95	61. 45	265. 25
1 empty-case conveyor	999. 02	8. 3	120. 36	24. 97	39. 96		185. 29	17. 50	39. 92	57. 42	242. 71
1 bulk-packing bench	105. 00	8. 3	12. 65	2. 63	4. 20		19. 48		4. 21	4. 21	23. 69
1 case-sealing station	110. 53	8. 3	13. 32	2. 76	4. 42		20. 50		4. 39	4. 39	24. 89
2 spring lifters	38. 00	1. 0	38. 00	. 95	1. 52		40. 47		1. 53	1. 53	42. 00
1 carton closer and sealer						192. 00	192. 00	7. 70	([9])	7. 70	199. 70
1 8-foot rotary packing table						84. 00	84. 00	5. 85	([9])	5. 85	89. 85
Total	15, 265. 30						3, 140. 85			716. 35	3, 857. 20

Total hourly equipment cost $1. 929

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes cost of 8 candling lights and auxiliary shelves and benches.
[7] Includes power cost for drive units, candling lights, and inventory system.
[8] Included in power cost of manual graders.
[9] Maintenance performed by company from which equipment is leased.

TABLE 12.—*System A (manual candling): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 114,000 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
6 manual egg graders [6]	14, 121. 00	8. 3	1, 701. 33	353. 03	564. 84		2, 619. 20	[7] 86. 10	564. 64	650. 74	3, 269. 94
6 inventory systems, complete	4, 926. 00	8. 3	593. 49	123. 15	197. 04		913. 68	([8])	196. 95	196. 95	1, 110. 63
6 carton racks	324. 00	8. 3	39. 04	8. 10	12. 96		60. 10		12. 98	12. 98	73. 08
1 package conveyor	1, 267. 50	8. 3	152. 71	31. 69	50. 70		235. 10	26. 20	50. 67	76. 87	311. 97
1 empty-case conveyor	1, 167. 77	8. 3	140. 70	29. 19	46. 71		216. 60	26. 20	46. 70	72. 90	289. 50
1 bulk-packing bench	105. 00	8. 3	12. 65	2. 63	4. 20		19. 48		4. 15	4. 15	23. 63
1 case-sealing station	110. 53	8. 3	13. 32	2. 76	4. 42		20. 50		4. 41	4. 41	24. 91
3 spring lifters	57. 00	1. 0	57. 00	1. 43	2. 28		60. 71		2. 30	2. 30	63. 01
1 carton closer and sealer						288. 00	288. 00	7. 70	([9])	7. 70	295. 70
1 8-foot rotary packing table						84. 00	84. 00	5. 85	([9])	5. 85	89. 85
Total	22, 078. 80						4, 517. 37			1, 034. 85	5, 552. 22

Total hourly equipment cost $2. 776

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes cost of 12 candling lights and auxiliary shelves and benches.
[7] Includes power cost for drive units, candling lights, and inventory system.
[8] Included in power cost of manual graders.
[9] Maintenance performed by company from which equipment is leased.

TABLE 13.—*System B (manual packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 34,640 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1 mass infeed candler	2,997.00	8.3	310.00	74.93	119.88		504.81	[6] 185.85	115.84	301.69	806.50
1 scale, frame, and crossfeed	2,750.00	8.3	331.33	68.75	110.00		510.08	[7] 17.50	106.26	123.76	633.84
1 inventory system, complete	986.00	8.3	118.80	24.65	39.44		182.89	([8])	38.14	38.14	221.03
6 manual-packaging units	1,950.00	8.3	234.94	48.75	78.00		361.69		75.26	75.26	436.95
Carton racks	162.00	8.3	19.52	4.05	6.48		30.05		6.50	6.50	36.55
1 package conveyor	975.00	8.3	117.47	24.38	39.00		180.85	8.75	37.63	46.38	227.23
1 empty-case conveyor	833.00	8.3	100.36	20.83	33.32		154.51	8.75	32.17	40.92	195.43
1 bulk-packing bench	105.00	8.3	12.65	2.62	4.20		19.47		4.03	4.03	23.50
1 10-foot section wheel conveyor	40.60	8.3	4.89	1.01	1.62		7.52		1.60	1.60	9.12
1 case-sealing station	110.53	8.3	13.32	2.76	4.42		20.50		4.28	4.28	24.78
1 vacuum-lifter assembly	568.49	5.0	113.70	14.21	22.74		150.65	5.85	21.92	27.77	178.42
1 carton closer and sealer						192.00	192.00	7.70	([9])	7.70	199.70
1 8-foot rotary packing table						84.00	84.00	5.85	([9])	5.85	89.85
Total	11,477.62						2,399.02			683.88	3,082.90

Total hourly equipment cost $1.541

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes power cost of inventory system.
[7] Includes power cost for main drive.
[8] Included in power cost for mass infeed candler.
[9] Maintenance performed by company from which equipment is leased.

TABLE 14.—*System B (automatic packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 34,640 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1 mass infeed candler	2,997.00	8.3	310.00	74.93	119.88		504.81	[6] 185.85	115.84	301.69	806.50
1 scale, frame, and crossfeed	2,750.00	8.3	331.33	68.75	110.00		510.08	[7] 17.50	106.26	123.76	633.84
1 inventory system, complete	986.00	8.3	118.80	24.65	39.44		182.89	([8])	38.14	38.14	221.03
3 manual-packaging units	975.00	8.3	117.47	24.38	39.00		180.85		37.63	37.63	218.48
3 automatic-packaging units	10,500.00	8.3	1,265.06	262.50	420.00		1,947.56		405.72	405.72	2,353.28
1 package conveyor	975.00	8.3	117.47	24.38	39.00		180.85	8.75	37.63	46.38	227.23
1 empty-case conveyor	833.00	8.3	100.36	20.83	33.32		154.51	8.75	32.17	40.92	195.43
1 bulk-packing bench	105.00	8.3	12.65	2.62	4.20		19.47		4.03	4.03	23.50
1 10-foot section wheel conveyor	40.60	8.3	4.89	1.01	1.62		7.52		1.60	1.60	9.12
1 case-sealing station	110.53	8.3	13.32	2.76	4.42		20.50		4.28	4.28	24.78
1 vacuum-lifter assembly	568.49	5.0	113.70	14.21	22.74		150.65	[9] 5.85	21.92	27.77	178.42
3 carton dispensers	900.00	8.3	108.43	22.50	36.60		166.93	1.32	34.78	36.10	203.03
1 carton closer and sealer						192.00	192.00	7.70	([10])	7.70	199.70
1 8-foot rotary packing table						84.00	84.00	5.85	([10])	5.85	89.85
Total	21,740.62						4,302.62			1,081.57	5,384.19

Total hourly equipment cost $2.692

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment item on basis of initial cost.
[6] Includes power cost of inventory system.
[7] Includes power cost for main drive.
[8] Included in power cost for mass infeed candler.
[9] 1 vacuum pump has sufficient capacity for 1 vacuum-lifter assembly and automatic packers on 1 machine.
[10] Maintenance performed by company from which equipment is leased.

TABLE 15.—*System B (manual packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 69,280 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
2 mass infeed candlers	5, 994. 00	8. 3	722. 17	149. 85	239. 76		1, 111. 78	[6] 371. 70	240. 85	612. 55	1, 724. 33
2 scales, frames, and crossfeeds	5, 500. 00	8. 3	662. 65	137. 50	220. 00		1, 020. 15	[7] 35. 00	220. 96	255. 96	1, 276. 11
2 inventory systems, complete	1, 972. 00	8. 3	237. 59	49. 30	78. 88		365. 77	([8])	79. 23	79. 23	445. 00
12 manual-packaging units	3, 900. 00	8. 3	469. 88	97. 50	156. 00		723. 38		156. 80	156. 80	880. 18
Carton racks	324. 00	8. 3	39. 04	8. 10	12. 96		60. 10		13. 00	13. 00	73. 10
1 package conveyor	1, 256. 00	8. 3	151. 33	31. 40	50. 24		232. 97	17. 50	50. 39	67. 89	300. 86
1 empty-case conveyor	911. 00	8. 3	109. 76	22. 78	36. 44		168. 98	17. 50	36. 63	54. 13	223. 11
1 bulk-packing bench	105. 00	8. 3	12. 65	2. 63	4. 20		19. 48		4. 15	4. 15	23. 63
2 10-foot section wheel conveyors	81. 20	8. 3	9. 78	2. 03	3. 25		15. 06		3. 49	3. 49	18. 55
1 case-sealing station	110. 53	8. 3	13. 32	2. 76	4. 42		20. 50		4. 48	4. 48	24. 98
2 vacuum-lifter assemblies	1, 136. 98	5. 0	227. 40	28. 42	45. 48		301. 30	[9] 11. 70	22. 87	34. 57	335. 87
1 carton closer and sealer						192. 00	192. 00	7. 70	([10])	7. 70	199. 70
1 8-foot rotary packing table						84. 00	84. 00	5. 85	([10])	5. 85	89. 85
Total	21, 290. 00						4, 315. 47			1, 299. 80	5, 616. 27

Total hourly equipment cost $2. 808

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes power cost for inventory system.
[7] Includes power cost for main drive.
[8] Included in power cost for mass infeed candler.
[9] 1 vacuum pump has sufficient capacity for 1 vacuum-lifter assembly.
[10] Maintenance performed by company from which equipment is leased.

TABLE 16.—*System B (automatic packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 69,280 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
2 mass infeed candlers	5,994.00	8.3	722.17	149.85	239.76		1,111.78	[6] 371.70	240.85	612.55	1,724.33
2 scales, frames, and crossfeeds	5,500.00	8.3	662.65	137.50	220.00		1,020.15	[7] 35.00	220.96	255.96	1,276.11
2 inventory systems, complete	1,972.00	8.3	237.59	49.30	78.88		365.77	([8])	79.23	79.23	445.00
6 manual-packaging units	1,950.00	8.3	234.94	48.75	78.00		361.69		78.40	78.40	440.09
6 automatic-packaging units	21,000.00	8.3	2,530.12	525.00	840.00		3,895.12		843.88	843.88	4,739.00
1 package conveyor	1,256.00	8.3	151.33	31.40	50.24		232.97	17.50	50.39	67.89	300.86
1 empty-case conveyor	911.00	8.3	109.76	22.78	36.44		168.98	17.50	36.63	54.13	223.11
1 bulk-packing bench	105.00	8.3	12.65	2.63	4.20		19.48		4.15	4.15	23.63
2 10-foot section wheel conveyors	81.20	8.3	9.78	2.03	3.25		15.06		3.49	3.49	18.55
1 case-sealing station	110.53	8.3	13.32	2.76	4.42		20.50		4.48	4.48	24.98
2 vacuum-lifter assemblies	1,136.98	5.0	227.40	28.42	45.48		301.30	[9] 11.70	38.07	49.77	351.07
6 carton dispensers	1,800.00	8.3	216.87	45.00	72.00		333.87	2.64	72.27	74.91	408.78
1 carton closer and sealer						192.00	192.00	7.70	([10])	7.70	199.70
1 8-foot rotary packing table						84.00	84.00	5.85	([10])	5.85	89.85
Total	41,816.41						8,122.67			2,142.39	10,265.06

Total hourly equipment cost $5.132

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes power cost for inventory system.
[7] Includes power cost for main drive.
[8] Included in power cost for mass infeed candler.
[9] 1 vacuum pump has sufficient capacity for 1 vacuum-lifter assembly and automatic packers on 1 machine.
[10] Maintenance performed by company from which equipment is leased.

TABLE 17.—*System B (manual packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 103,920 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
3 mass infeed candlers	8,991.00	8.3	1,083.25	224.77	359.64		1,667.66	[6] 557.55	360.75	918.30	2,585.96
3 scales, frames, and crossfeeds	8,250.00	8.3	993.98	206.25	330.00		1,530.23	[7] 52.50	331.12	383.62	1,913.85
3 inventory systems, complete	2,958.00	8.3	356.39	73.95	118.32		548.66	([8])	118.77	118.77	667.43
18 manual-packaging units	5,850.00	8.3	704.81	146.25	234.00		1,085.06		234.58	234.58	1,319.64
Carton racks	486.00	8.3	58.55	12.15	19.44		90.14		19.50	19.50	109.64
1 package conveyor	1,538.00	8.3	185.30	38.45	61.52		285.27	26.25	61.73	87.98	373.25
1 empty-case conveyor	1,169.00	8.3	140.84	29.23	46.76		216.83	26.25	46.91	73.16	289.99
1 bulk-packing bench	105.00	8.3	12.65	2.63	4.20		19.48		4.44	4.44	23.92
3 10-foot section wheel conveyors	121.80	8.3	14.75	3.05	4.87		22.67		5.19	5.19	27.86
1 case-sealing station	110.53	8.3	12.32	2.76	4.42		20.50		4.69	4.69	25.19
3 vacuum-lifter assemblies	1,705.47	5.0	341.09	42.64	68.22		451.95	[9] 17.55	45.93	63.48	515.43
1 carton closer and sealer (double)						288.00	288.00	7.70	([10])	7.70	295.70
1 8-foot rotary packing table						84.00	84.00	5.85	([10])	5.85	89.85
Total	31,284.80						6,310.45			1,927.26	8,237.71

Total hourly equipment cost $4.119

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes power cost for inventory system.
[7] Includes power cost for main drive.
[8] Included in power cost for mass infeed candler.
[9] 1 vacuum pump has sufficient capacity for 1 vacuum-lifter assembly.
[10] Maintenance performed by company from which equipment is leased.

TABLE 18.—*System B (automatic packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 103,920 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
3 mass infeed candlers	8, 991. 00	8. 3	1, 083. 25	224. 77	359. 64		1, 667. 66	[6] 557. 55	360. 75	918. 30	2, 585. 96
3 scales, frames, and crossfeeds	8, 250. 00	8. 3	993. 98	206. 25	330. 00		1, 530. 23	[7] 52. 50	331. 12	383. 62	1, 913. 85
3 inventory systems, complete	2, 958. 00	8. 3	356. 39	73. 95	118. 32		548. 66	([8])	118. 77	118. 77	667. 43
9 manual-packaging units	2, 925. 00	8. 3	352. 41	73. 13	117. 00		542. 54		117. 29	117. 29	659. 83
9 automatic-packaging units	31, 500. 00	8. 3	3, 795. 18	787. 50	1, 260. 00		5, 842. 68		1, 263. 98	1, 263. 98	7, 106. 66
1 package conveyor	1, 538. 00	8. 3	185. 30	38. 45	61. 52		285. 27	26. 25	61. 73	87. 98	373. 25
1 empty-case conveyor	1, 169. 00	8. 3	140. 84	29. 23	46. 76		216. 83	26. 25	46. 91	73. 16	289. 99
1 bulk-packing bench	105. 00	8. 3	12. 65	2. 63	4. 20		19. 48		4. 44	4. 44	23. 92
3 10-foot section wheel conveyors	121. 80	8. 3	14. 75	3. 05	4. 87		22. 67		5. 19	5. 19	27. 86
1 case-sealing station	110. 53	8. 3	13. 32	2. 76	4. 42		20. 50		4. 69	4. 69	25. 19
3 vacuum-lifter assemblies	1, 705. 47	5. 0	341. 09	42. 64	68. 22		451. 95	[9] 17. 55	56. 73	74. 28	526. 23
9 carton dispensers	2, 700. 00	8. 3	325. 30	67. 50	108. 00		500. 80	3. 96	108. 40	112. 36	613. 16
1 carton closer and sealer (double)						288. 00	288. 00	7. 70	([10])	7. 70	295. 70
1 8-foot rotary packing table						84. 00	84. 00	5. 85	([10])	5. 85	89. 85
Total	62, 073. 80						12, 021. 22			3, 177. 61	15, 198. 88

Total hourly equipment cost $7. 599

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes power cost for inventory system.
[7] Includes power cost for main drive.
[8] Included in power cost for mass infeed candler.
[9] 1 vacuum pump has sufficient capacity for 1 vacuum-lifter assembly and automatic packers on 1 machine.
[10] Maintenance performed by company from which equipment is leased.

TABLE 19.—*System C (automatic packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 60,000 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1 full-case conveyor	40. 60	8. 3	4. 89	1. 02	1. 62		7. 53		1. 66	1. 66	9. 19
1 empty-case conveyor	94. 20	8. 3	11. 35	2. 35	3. 77		17. 47		3. 84	3. 84	21. 31
1 case-sealing station	110. 53	8. 3	13. 32	2. 76	4. 42		20. 50		4. 50	4. 50	25. 00
1 35-case-per-hour automatic egg-grading and packing machine [6]						[7] 13, 200. 00	13, 200. 00	320. 35	[8] 50. 00	370. 35	13, 570. 35
2 carton closers and sealers						384. 00	384. 00	5. 85	([9])	5. 85	389. 85
Total	245. 33						13, 629. 50			386. 20	14, 015. 70

Total hourly equipment cost $7. 008

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes all auxiliary equipment required to operate system and not listed above.
[7] Based on minimum annual rental for 1 equipment unit (first 60,000 cases, $0.22 per case; $0.11 per case for all over 60,000 cases); 1963 rental rates.
[8] This is for incidental maintenance expenses not covered by maintenance provided by equipment company as stipulated in rental agreement.
[9] Maintenance performed by company from which equipment is leased.

TABLE 20.—*System C (automatic packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 120,000 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
2 full-case conveyors	81. 20	8. 3	9. 78	2. 03	3. 25		15. 06		3. 32	3. 32	18. 38
2 empty-case conveyors	188. 40	8. 3	22. 70	4. 71	7. 54		34. 95		7. 68	7. 68	42. 63
2 case-sealing stations	221. 06	8. 3	26. 63	5. 53	8. 84		41. 00		9. 00	9. 00	50. 00
2 35-case-per-hour automatic egg-grading and packing machines [6]						[7] 26, 400. 00	26, 400. 00	640. 70	[8] 100. 00	740. 70	27, 140. 70
4 carton closers and sealers						768. 00	768. 00	11. 70	([9])	11. 70	779. 70
Total	490. 66						27, 259. 01			772. 40	28, 031. 41

Total hourly equipment cost $14. 016

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Includes all auxiliary equipment required to operate system and not listed above.
[7] Based on minimum annual rental for 1 equipment unit (first 60,000 cases, $0.22 per case; $0.11 per case for all over 60,000 cases); 1963 rental rates.
[8] This is for incidental maintenance expenses not covered by maintenance provided by equipment company as stipulated in rental agreement.
[9] Maintenance performed by company from which equipment is leased.

TABLE 21.—*System D (automatic packaging): Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours' annual use and annual volume of 104,360 cases*

Equipment item (number)	Initial cost [1]	Expected life	Ownership costs					Operating costs			Total annual cost
			Depreciation	Interest [2]	Insurance and taxes [3]	Rent	Total	Power [4]	Maintenance [5]	Total	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1 full-case conveyor	700.00	8.3	84.34	17.50	28.00		129.84	[6]	27.99	27.99	157.83
1 empty-case conveyor	200.00	8.3	24.10	5.00	8.00		37.10		7.94	7.94	45.04
1 mass infeed candler	2,309.26	8.3	278.22	57.73	92.37		428.32	[7] 283.75	92.63	376.38	804.70
1 scale assembly	9,061.94	8.3	1,091.80	226.55	362.48		1,680.83	7.70	363.29	370.99	2,051.82
1 inventory system	1,086.86	8.3	130.95	27.17	43.47		201.59	[6]	43.51	43.51	245.10
1 egg-delivery conveyor	6,473.52	8.3	779.94	161.84	258.94		1,200.72	17.50	259.46	276.96	1,477.68
3 manual-packaging units	2,485.34	8.3	299.44	62.13	99.41		460.98		99.67	99.67	560.65
5 automatic-packaging units	14,464.42	8.3	1,742.70	361.61	578.58		2,682.89	[8] 25.05	579.78	604.83	3,287.72
6 package dispensers	2,604.03	8.3	313.74	65.10	104.16		483.00		104.36	104.36	587.36
8 package conveyors with control kits	3,087.19	8.3	371.95	77.18	123.49		572.62		123.68	123.68	696.30
1 carton conveyor	913.46	8.3	110.06	22.84	36.54		169.44	11.65	36.65	48.30	217.74
1 filler-flat conveyor and packing table	671.98	8.3	80.96	16.80	26.88		124.64	5.85	26.90	32.75	157.39
1 case-sealing station	110.53	8.3	13.32	2.76	4.42		20.50		4.52	4.52	25.02
1 vacuum-lifter assembly	568.49	5.0	113.70	14.21	22.74		150.65	5.85	22.75	28.60	179.25
1 bulk-packing bench	105.00	8.3	12.65	2.63	4.20		19.48		4.34	4.34	23.82
Wooden platforms	200.00	8.3	24.10	5.00	8.00		37.10		8.13	8.13	45.23
1 double closer and sealer						288.00	288.00	7.70	[9]	7.70	295.70
1 8-foot rotary packing table						84.00	84.00	5.85	[9]	5.85	89.85
Total	45,042.02						8,771.70			2,176.50	10,948.20

Total hourly equipment cost $5.474

[1] 1963 f.o.b. prices plus installation cost.
[2] 5 percent of average investment (computed at 50 percent of initial cost).
[3] 4 percent of initial investment.
[4] Assumed rate of $0.025 per kilowatt-hour.
[5] Total estimated annual maintenance cost prorated to equipment items on basis of initial cost.
[6] Included in power cost for mass infeed candler.
[7] Includes power cost for full-case conveyor and inventory system.
[8] Includes power cost for main drive and carton dispensers.
[9] Maintenance performed by company from which equipment is leased.

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